Practical Physiology.

CALLAHAN.

A

GUIDE TO ACTUAL WORK

—IN—

Practical Physiology

WITH METHODS

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DESIGNED TO AID IN THE STUDY OF NATURE.

It develops a boy more to earn a dime than to receive a dollar as a gift.

CHICAGO.
A. FLANAGAN, PUBLISHER.
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Preface.

The experiments, observations, and directions for examination and dissections given in this book, are taken from notes of class work, and are suggestive of what may be done to supplement the matter of the text-book, so that the pupil may have a better knowledge of the foundation upon which Physiology rests, and, at the same time, have his memory aided by impressions made through the senses. "Sight takes the lead as a channel of perception."

The pupils are led to *work*, and to do their own thinking by *earning* facts that are placed within their reach. *It develops a boy more to earn a dime than to receive a dollar as a gift.*

"Real knowledge in science means personal acquaintance with the facts, be they few or many."—*Huxley*.

The experiments given require no great expense, and can be done in any of the *common schools*. They will suggest many others equally as good, which may be contrived by the teacher and the pupils.

In many of the observations, it has been recognized that Physiology is really related to other sciences, and that the human body has many things in common with other organisms.

Drawings have been used where they have been thought necessary for illustration.

J. M. CALLAHAN.

Mitchell, Ind., Jan. 2, 1893.

Contents.

INTRODUCTION.

1. Many valuable ideas concerning the relations of living things to their surroundings may be obtained by observing some animals and plants which can be found near the school.

2. Notice the adaptation of the cray-fish to the conditions in which it is found. Cause it to swim backwards and forwards. Explain the movements. Keep it until hungry. Feed it some meat and watch it eat. How does it eat? Why are the eyes placed on stalks? Of what use are the antennæ? Is the color of the animal adapted to the place in which it is found? Compare the large forceps with the legs.

3. Observations may be made of frogs, fishes, grasshoppers, etc. A study of some of the lower forms of animals would teach a great amount of what is known of the human body.

4. Get candy jars to use as aquaria for frogs, cray-fish, minnows, etc., which may be brought to the class for examination or for dissection.

Some water from the pond, containing frog's eggs, may be placed into a glass jar and kept on the teacher's desk. All will be interested in watching the development of the eggs into tadpoles, and in seeing the tadpole pass through successive stages of life until it becomes a frog. In this way the pupil may be led to see and think for himself.

TISSUES.

Examine the leg of a frog or chicken, observing the various kinds of tissues — *epidermal*, *connective*, *muscular*, *osseous*, *nerve*, *fatty*, and *cartilaginous*

BONES.

1. Examine the skeleton of a cat or dog, if parts of the human skeleton cannot be obtained. Many bones of different animals may be found in the fields, and can be used to advantage in the class.

2. Get a fresh bone, and examine for the periosteum, cartilage and attachment of ligaments.

Examine the distribution of blood-vessels in the periosteum, and the bone. Cut through the outer covering of a joint to observe the synovial fluid.

3. Notice the fitting of joints.

4. Place a rib or chicken bone in vinegar or some dilute acid, for a few days. Explain the result.

5. Burn a bone and carefully remove from the fire. Result.

6. Saw a bone through condyle and shaft. Compare.

7. Distinguish tendons from ligaments.

8. Examine the wing-bones of a chicken, and notice their special adaptation to purposes of flight by containing air-cavities instead of marrow.

9. The clavicle is wanting in the horse and the cow. Why is it not needed? Why are the clavicles of birds united forming a forked bone (wish-bone)?

10. In birds, the humerus is larger than the femur. Why?

11. By noticing the skeleton of a horse it will be seen that the wrist and heel are raised to the middle of the leg, the metacarpals and metatarsals being greatly elongated. What is called the *knee*, in the hind leg, is the *heel*.

12. Count the vertebrae in the skeleton of a frog, of a horse, of a snake, and of a fish.

13. Notice that frogs have no ribs. In the turtle the ribs are expanded to form the dorsal part of its shell.

14. Observe in serpents that the lower extremities of the ribs have no cartilage, and that they aid in crawling by being worked (under the skin) like feet.

15. Make a drawing of the humerus; the radius and ulna; the femur.

16. After mixing madder with the food of some animal for several days it can be demonstrated by killing it that the coloring matter causes the bones to become red.

17. Notice and illustrate the following points peculiar to the human hand:—

(1.) If the center of the palm be placed on a sphere and the digits equally spread, their tips lie in the same plane.

(2.) If a straight-edge be placed transversely across the palm, the fingers may press upon it with nearly equal force.

(3.) The thumb can be made to oppose each finger

(4.) The index finger can be used as a pointer.

18. The skeleton of the female differs from that of the male in the following points:—

1. The head is smaller.

2. The trunk is longer.

3. The clavicle is less curved and longer.

4. The ribs are more curved.

5. The pelvis { Transverse diameter greater. Illium thinner. Sacrum broader and shorter.

6. The phalanges are slimmer.

7. The femur has a longer neck, and is more nearly rectangular.

MUSCLES.

1. In the legs of a rabbit or some other animal, examine the muscular substance, the muscular sheath, the tendons, and their attachments to the bones

Notice that the muscles which move the foot and toes are placed at a considerable distance from the foot.

Observe how the tendon shapes into the *perimysium.*

Notice how bands of connective tissues act as pulleys to hold the tendons down at the joints.

2. In the rabbit examine the arrangement of the muscles of the thorax, abdomen, leg and neck.

3. In the cray-fish notice the arrangement of the muscles with reference to their motion.

4. Over the biceps muscles, bandage the arm with writing paper. Quickly flex the forearm. Result.

5. Hold a book at arm's length two minutes. Result.

6. Place a large flat weight on the table. Grasp the weight with the right hand, palm up, and turn the weight to the right then to the left. Why are gimlets made to turn to the right?

7. Examine the tendons of your own body. Grasp the powerful tendons of the hip muscles under the knee; those near the ankle; of the forearm at the wrist; of the arm at the elbow.

8. With a moderately powerful microscope, the structure of striated muscular fibre can be seen.

9. After the anatomy of the principal muscles of the body is learned, the three different classes of levers may be described, and movements of the body can be pointed out to illustrate each.

DIGESTION.

1. Obtain a rabbit. (A cat or rat will do). Cut through abdominal wall in the middle line from the breast-bone to the pelvis. Cut outward from the middle of the cut and turn back the flaps.

Feel the lining of the abdomen, the *peritoneum*.

Without moving the coiled intestines, observe variations in size and shape.

Notice the size, shape and position of the *liver* and *stomach*, and observe how they fit together. Observe the entrance of the *esophagus* into the stomach. The small red body just behind the stomach is the *spleen*, or "*milt*," which sometimes becomes enlarged in malarial fevers, producing what is called "*ague cake*."

Make a drawing of the stomach.

Below the stomach the *duodenum* forms a loop in which is situated the *pancreas*. Find the pancreatic duct entering the intestines. Trace the intestines through all their windings, and observe how completely the mesentery holds all the parts in place.

Turn the liver forward, and notice on its back surface the dark *bile sac*, and trace its duct.

Pull back the liver and examine the thin muscular partition, the *diaphragm*, which extends across the body between the chest and the abdomen. The thin, transparent, central part of the diaphragm is its tendon.

Cut out about an inch of the small intestine in the middle of its course, slit it open lengthwise, wash it thoroughly, and examine under water, the inner surface with a lens, to see the thread-like *villi*.

Note the different coats.

Prepare a section of the large intestine. Note the absence of villi.

2. Watch different animals eat. By watching the quick, snapping movement by which a dog seizes a piece of meat and the rapidity with which he swallows it, it will be seen how very imperfectly the function of mastication is performed by the *carnivorous* animals; while the slow, lateral movement of the jaw and the continued grinding of the food, in the horse, shows the much greater relative importance of mastication in the *herbivora*.

3. Observe that vegetable food in the *natural* state requires more mastication than animal food.

Notice the more or less indigestible envelopes of nuts, seeds and grains. Observe that cooking lessens the work of mastication. "The millstone and the oven do for mankind much of the work accomplished by the molar teeth of the herbivora."

4. Get the skull of a dog, a sheep, and of a rabbit, to illustrate the difference in jaws and teeth in the *carnivora*, *herbivora* and *rodentia*.

Observe the *articulation of the jaws*.

(1.) In the carnivora, a perfect hinge-joint, permitting a free up and down, but no lateral motion.

(2.) In the herbivora, the articulation is looser, permitting a free lateral movement of the lower jaw.

(3.) In the rodentia, the lower jaw articulates into a longitudinal groove, in the base of the skull, giving it a free

forward and backward movement, needed in nibbling or gnawing.

Observe the *teeth*.

(1.) In the carnivora.

1. The canines developed for seizing and holding the prey.

2. The molars, with sharp edges, closing past each other, adapted for cutting.

(2.) In the herbivora,

1. The canines, rudimentary or absent.

2. The molars, with rough and flattened surfaces, for grinding.

(3.) In the rodentia,

1. The incisors, of enormous size, grow constantly and are only kept from becoming too long by being continually worn away by gnawing. The enamel of the incisors is found only on the front surface, and the back part of the tooth being worn away more rapidly, causes the teeth to be kept sharp. The incisors of rodents are never shed after the animal is born.

2. The molar teeth of rodents have rough, flattened crowns, but are grooved in a longitudinal direction, instead of transversely as in ths *herbivora*.

5. Notice that man, by the charater of his dentition, and by having all of the three motions of the jaws, is adapted for a mixed diet.

6. Get specimens of different kinds of teeth. Saw them open or break them with a hammer and observe their structure.

7. With the help of a mirror, locate the different teeth in your own mouth.

8. Pupils may be shown how to take care of their teeth. Their teeth may be examined by the teacher, who may offer suggestions to each person concerning each particular set of teeth. Those who have good teeth should be shown how to keep them so. If they are crooked, they can be straightened in young people from 10 to 17 years of age. If they are decaying, the skilled dentists can, in most cases, save them by filling. The *last* resort of all is to lose a tooth by having it extracted.

9. Observe the process of *swallowing* a piece of bread.

10. Notice how the larynx is drawn up during deglutition. Why?

11. Observe how difficult it is to swallow with the mouth open. Why?

With no food in the mouth, swallow three or four times in rapid succession, until the mouth is emptied of any saliva it may contain, when it will be found impossible to repeat the movement of swallowing until more saliva has been secreted. This proves that a pressure of some substance upon the sensitive mucous membrane at the back of the mouth is necessary as a stimulus to cause swallowing.

12. Notice how difficult it is to swallow or even chew, when there is little saliva.

13. Examine the stomach of a calf, when killed by the butcher. All animals that chew the cud (ruminants) have the most complex stomach. It is divided into four chambers :

(1.) The *rumen* (paunch) receives the half-masticated food when first swallowed ;

(2.) The *reticulum*, where it passes to be made into little balls to be returned to the mouth ;

(3.) The *psalterium* or *leaflet* which receives the food that has been thoroughly masticated ;

(4.) The *abomasus*, or true stomach, from which, in the calf the rennet is obtained.

14. Watch a cow chew her cud. Get it from her mouth and examine it. Can she lose her cud? Some persons, when their cows get sick and do not eat, make them a cud from an old greasy rag. Will this cure them?

FOOD.

15. Examine specimens of cereals, starches, sugars, oil, etc. Many interesting facts may be brought out about the use of those substances as foods.

16. Observe different nitrogenous substances.

(1.) Boil an egg hard. The white is *albumen* hardened by heat.

(2.) Thoroughly wash a piece of lean meat in water, squeezing and pressing it well in a lemon-squeezer. The whitish, stringy mass obtained is *fibrine*. Boil the water in which the meat has been washed, and the *albumen* which was dissolved in it will be coagulated by the heat.

(3.) Pour some vinegar or any weak acid into some sweet milk. The whitish substance, called the *curd*, which separates from it, is *casein*, the principal constituent of cheese.

(4.) Boil a bone for several hours, and most of the animal matter will be dissolved. The substance dissolved is *gelatine*. Glue is simply gelatine obtained by boiling the hoofs, horns and other parts of animals.

(5.) *Gluten* may be obtained by placing a few spoonfuls of flour into a muslin bag or cloth, and squeezing it well in a bowl of water. The starch causes the water to become milky, and it settles to the bottom in a white powder. The sticky, yellowish-white substance in the cloth is the gluten.

17. Examine non-nitrogenous foods.

(1.) Boil a small quantity of rice, bread, potatoes or flour in a little water in a test tube or small bottle. Add a drop or two of tincture of iodine and the mixture will turn blue. This proves the presence of *starch*.

(2.) Pick out some of the little white grains from raisins as an example of *grape-sugar.* Cooking sugar is *cane-sugar. Milk-sugar* can be purchased at the drug-store.

(3.) Place some thin starch paste into a small glass. Place some common white sugar into another one. Carefully pour a small amount of sulphuric acid upon the mixtures and they turn black. The sulphuric acid has united the oxygen and hydrogen of the sugar to form water, and the *carbon* remains as a charred mass.

(4.) Touch the tongue to the back of a postage stamp and notice the sweet tast of *dextrine.* Starch is converted into this kind of sugar by heat.

(5.) Name some fats that are solid at ordinary temperatures. Name some liquid fats.

DIGESTIVE JUICES.

18. Look at a small quantity of saliva under the microscope with a high power.

19. Test with neutral litmus paper the reaction of a drop of saliva. It will be found to be alkaline.

20. Hold a small quantity of boiled dilute starch paste in the mouth. In a few minutes it will have a sweetish taste, owing to the changing of starch into sugar.

21. Notice that bread tastes sweet after it is well wet with saliva.

22. Chew pieces of toast or the brown crust of bread. The crust is sweeter and dissolves more readily because the

greater heat which it received changed the starch to dextrine while it was cooking.

23. Prepare some starch mucilage by rubbing a gram of starch into a thin paste with cold water, pouring the mixture into a glass containing 12 cu. in. of boiling water. Boil a few minutes and then let it cool. It should have no lumps in it.

24. To a spoonful of starch mucilage in a test-tube add a drop or two of a moderately strong solution of iodine. An indigo color will be produced. Add water if the color is very dark.

25. In a test-tube mix equal quantities of starch, and saliva diluted with five to ten times as much water. Place the tube in a bowl of water warmed to 100° Fahr. Every minute or two take a drop of the mixture and add it to a drop of iodine on a common plate. The color produced, at first blue, will later become blue-violet, red-violet, red-brown, and a light brown yellow, according to the relative amounts of starch and dextrin present. Finally there will be no color, no more starch or dextrin being left.

26. In a test-tube place a few drops of starch paste and a teaspoonful of saliva. Fill the tube half full of water Place the mixture in a warm place for ten minutes. Add one of Fehling's Test Tablets, * as a test for sugar. Mix and boil. A turbid brick-red dust will be thrown down; showing that sugar is present.

* A solution of caustic potash and blue vitrol will do for the same purpose.

27. Artificial gastric juice may be prepared by warming water, containing hydrochloric acid, to "blood heat," and immersing into it small portions of the mucous membrane of the stomach of a pig.

(Pure pepsin from the drug store will serve the purpose in the following experiments:)

28. Get three four-ounce bottles, containing the peptic glands in the mucous membrane, which is immersed in dilute hydro-chloric acid.

BOTTLE 1. Keep the mixture *cool* and *still*. Add a small piece of meat, or boiled white of egg—*not minced.*

BOTTLE 2. Add meat or boiled white of egg—*minced.* Keep *still*, and heat to about 100° Fahr.

BOTTLE 3. Add meat or boiled white of egg—*minced.* Keep it continually agitated by shaking, and have it heated to 100° Fahr. The agitation is equivalent to the *peristaltic* action of the stomach.

Examine in two hours. The meat (or egg) of the *third* bottle will have nearly disappeared, that of the *second* will be only partially dissolved, and that of the first will probably show little or no signs of change.

This shows that *mastication*, *warmth* and *peristaltic* movements, all combine to promote digestion.

29. Prove that both *acid* and *pepsin* are necessary in digestion of nitrogenous foods. Make a solution of weak hydrochloric acid by adding one part of strong acid to 120

times as much water. Get a few grains of pepsin from the drug store. "Fairchild's Pepsin" is pure, and the necessary amount can be gotten for a few oents. Fill four small test-tubes or ounce bottles with the following fluids:—

1. Water.
2. Weak HCl.
3. Water and pepsin.
4. Weak HCl and pepsin.

(A two-grain capsule full of pepsin will be enough.) To each vessel add a small quantity (less than a spoonful) of egg-albumen prepared by dropping the white of an egg into slightly acidulated boiling water and stirring it as it falls. Place the mixtures in a basin of warm water, or near the stove, to keep them at "blood-heat," or slightly above. After an hour or two examine them. It will be found that the contents of one and three are unchanged; in two, the albumen is rendered slightly translucent; and in four the the material is more or less completely dissolved. This dissolved mass is now in a condition to be readily absorbed through the moist lining of the stomach and is known as "peptone."

30. Into four test-tubes place the following:—

Tube 1. Hydrochloric acid (5/8 cu. in.)

Tube 2. Artificial gastric juice (5/8 cu. in.)

Tube 3. Same as 2, but carefully neutralize with dilute sodium carbonate. (Na_2CO_3.)

Tube 4. Same as 2, but thoroughly boiled. Add the same quantity of *raw fibrin* to each and place in a water bath at about 99° Fahr. Examine from time to time.

In 1, the fibrin will swell and become transparent, but will not be dissolved, and will appear unaltered when neutralized.

In 2, the fibrin will be digested.

In 3, the fibrin will be unaltered.

In 4, the fibrin will be like that in 1. Now add acid again to 3, and place in the warm bath. Digestion will take place.

Conclusions.
- Acid alone (1) and pepsin (3) alone will not digest fibrin.
- Pepsin loses its power when heated to boiling point (4).
- Neutralization suspends, but does not destroy the action of the pepsin (3).

31. Take two test-tubes, with $\frac{5}{8}$ cu. in. of gastric juice and a small piece of fibrin in each. Place one in a warm place, and surround the other with ice. The fibrin in the first will be digested rapidly; that in the second very little or none. What is learned from this?

32. Get some ox-gall or sheep's-gall from the butcher, or if possible get the gall-bladder itself, cut it open and place the bile in a bottle for future use.

33. Test the reaction of bile with litmus paper. When fresh it is slightly *alkaline* or *neutral*.

34. Shake up some sweet-oil and water in a small bottle. They will not mix. Shake up some oil with bile, and a creamy mixture called an "emulsion" results.

35. Place in separate test-tubes,—

1. $1\frac{1}{4}$ cu. in. of bile and 2 drops of oleic acid.
2. $1\frac{1}{4}$ cu. in. of bile.
3. $1\frac{1}{4}$ cu. in. of water.

To each add $\frac{1}{61}$ cu. in. of butter, shake well, and immerse in warm water. The emulsion will last much longer in 1 than in 2; it will last much longer in 2 than in 3.

The emulsifying power of bile is slight; but in the presence of fatty acids it forms soaps which have a much greater emulsifying power.

36. Make a smooth starch paste such as is used to starch clothes. Place three tablespoonfuls in a glass tumbler, and while as warm as the mouth can bear it, stir into it three grains of Fairchild's Extract of Pancreas which can be gotten at the drug store. The paste becomes thinner, and is gradually changed into soluble starch, in a fluid condition.

37. Into a small bottle place two grains of the Extract of Pancreas, and half a tablespoonful of warm water. Shake for a few minutes, then add a tablespoonful of Cod liver Oil. Shake vigorously. A creamy mixture of oil and water, called an "emulsion," will result.

38. Into a small bottle place two spoonfuls of cold water, one grain of Extract of Pancreas and the same amount of

common soda. Shake, and add four spoonfuls of cold, fresh milk. Shake, and place the bottle in a basin of water as hot as the hand can bear. After 40 or 50 minutes, add a few drops of vinegar. No curd will be made, because the trypsin of the pancreatic ferment has digested the nitrogenous part of the milk, casein, (the curd) into a "peptone" which does not curd. "Peptonized milk," thus prepared is used as a food for infants who suffer from ill digestion.

39. Observe the appearance of the chyle in the lacteals of the mesentery of a rabbit a few hours after a meal.

Effect of alcohol.

40. Put a little of the white of egg into a test-tube or a tumbler; cover it with strong alcohol and note the effect. Strong alcohol has the same coagulating action on the brain and on the tissues generally, when taken into the system, absorbing waterfrom them, hardening them, and contracting them in bulk.

ABSORPTION.

Many simple experiments may be used to illustrate the physical processes by which the products of digestion are transferred from the intestinal canal to the circulating blood.

1. Place glass tubes of different sizes in a glass of water and notice that the water rises much higher in the smaller tubes.

2. Suspend a strip of blotting paper in colored water and notice the rise of the fluid through the pores of the paper.

Both of the above experiments illustrate capillary imbibation.

3. Fill a tumbler full of beans, fill the interspaces with water and cover them with a board disc which fits the inside of the tumbler. Place upon this iron weights and observe, after a few hours, how much the weights are lifted. This shows the force with which germinating seeds imbibe water, and illustrates molecular imbibation.

To Illustrate Osmosis.

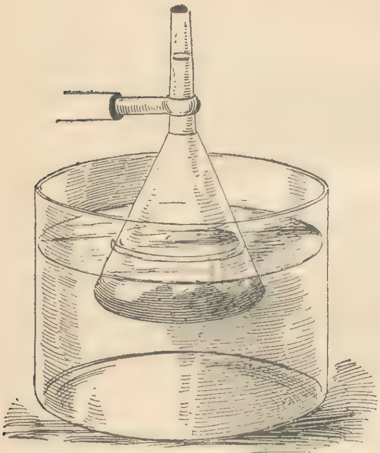
4. Fasten a six inch glass tube to a small bladder and pour into the open end of the tube a thick solution of sugar until the liquid stands an inch high in the tube. Immerse the bladder in a vessel of pure water keeping the tube so the liquid in it will be on a level with that outside. In a few hours observe:

(1.) That the liquid has raised in the tube.

(2.) That the water outside tastes sweet, and has sunk.

The liquid in the bladder being more dense than the water outside, draws it in through the bladder and will continue to do so until both liquids are of the same density. It is on this principle that absorbent vessels suck in liquids which are thinner than what they at first contain.

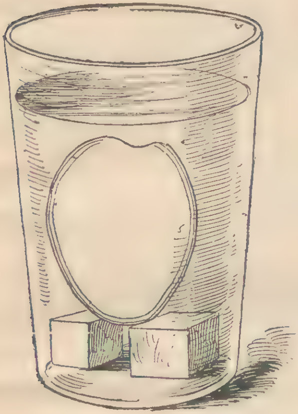
5. Try the same experiment by placing water in the bladder, and the sugar solution in the glass. Why does the water fall in the tube?



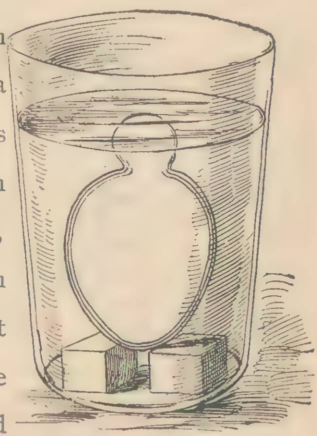
6. The last experiment may be varied by tying a piece of bladder, frog skin, or other animal membrane over the end of a glass funnel, filling the funnel with a strong solution of blue vitriol or sugar, and placing it inverted into a bowl of water.

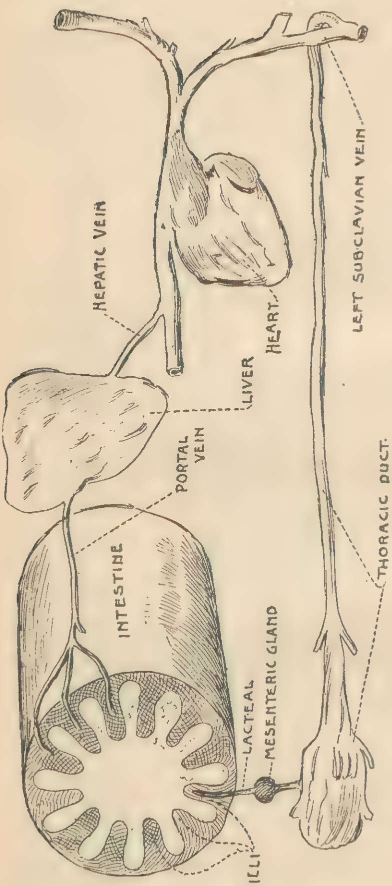
7. Cut off the stem of a thriftily growing woody plant, which is in full life, and plunge it at once into a thin solution of aniline blue or juice of the pokeberry. After a few hours split the stem and observe how high the aqueous solution has ascended. Place a growing plant under a perfectly dry jar in the light and notice drops of water gather on the white surface of the jar. Why?

8. Cut a leaf of a thriftily growing plant and immerse it at once into a test tube containing water. After exposing to the sunlight for a couple of hours the level of the water is lowered. Explain.



9. At the large end of an egg remove the shell from a space as large as a copper cent. Remove nearly as much of the outer shell membrane, but not breaking the inner shell membrane which lies below the air space. Immerse the egg in water, placing the small end down, and supporting it so it will remain in a vertical position. The water will pass toward the albumen much more rapidly than the albumen passes to the water, and as a result, the membrane becomes distended, bulges out through the opening in the egg shell, and if it be kept immersed in water, will finally burst. What would be the result if it were taken out of water and placed in the air?





10. Make a diagram showing the route taken by the digested food to get into the circulation. The digested foods are absorbed by blood vessels which form the portal vein, and by the lacteals which reach to the center of the villi.

What part of the food is taken by the portal vein to the liver?

What part passes through the thoracic duct?

What is the purpose of the mesenteric glands?

"As the rootlets of a plant soak up nourishment from the ground, so these villi take up digested food."

How do rootlets of plants absorb from the soil?

11. Occasionally, after an injury, bright-red streaks extend from the injured spot up the limb to small, firm, pain-

ful enlargements, called "knots" or "kernels." The red lines indicate the course of surface lymphatics, and the "kernels" are lymphatic glands. The glands are more easily found in the neck, armpits and groins.

12. Get a live frog and look for slight pulsations near the end of the backbone on each side. These are the movements of the *lymph hearts* which keep up the flow of lymph in the lymphatics. In man, the current is kept up by the movements of the body.

What color is the lymph? How does it resemble blood? Does the thoracic duct carry lymph as well as chyle?

CIRCULATION.

1. Observe the *rate of your pulse* in the position of standing, walking, sitting and lying down. Notice the rate and elevation of the pulse after running. Notice how long a time elapses before it returns to the usual rate.

Determine the rate of pulse in the horse or other lower animals.

2. Observe the *action of the heart* in a frog.

(1.) Kill it by wrapping in a piece of cloth moistened with chloroform.

(2.) Cautiously avoiding any large blood-vessels, open the abdomen lengthwise from the pelvis to breast-bone; with a forceps or a penknife raise the hinder part of the breast-bone; observe the heart lying next it, and a thin

membrane extending from it to the breast-bone; with a scissors cut the membrane close to the breast-bone; cut through the breast-bone in the middle line, and stretch its parts well out to the sides to disclose the heart and surrounding organs. Lay the frog on its back; stretch the fore limbs out to their fullest extent, and pin them down. The slow, regular movements of the heart will be seen. It will beat for considerable time.

(3.) Notice the alternate beats of the two auricles and the ventricle, and the synchronous beats of the two auricles.

(4.) Carefully slit the pericardium open in front and observe that the ventricle during contraction becomes pale and conical, and that its apex is thrown forward and upward.

(5.) Notice the pause or systole just before the auricle beats.

(6.) Watch the effect of applying gentle heat to the heart, by breathing upon it. Notice the effect of cooling it.

(7.) Remove the heart from the body. Does it beat? After it stops beating, notice the effect of holding in the palm of the hand.

(8.) Observe the result of sticking a needle slightly into the heart.

(9.) Cut through a ventricle at one-third the distance from the top, with a pair of sharp scissors, and notice that

the lower two-thirds of the ventricle ceases to beat, but the upper third, and the auricles will beat as before.

(10.) Carefully divide the auricles and attached portions of ventricle into two lateral halves, by a longitudinal incision, and each half will continue to beat.

3. For *examination of the heart*, that of a calf, a hog or sheep is of the most convenient size, but any heart will do. Instruct the butcher to get the heart and lungs entire. Notice the relation of the heart to the lungs. Point out the *right* and *left* side, the *apex* and the *base*. Note carefully the *pericardium*. Notice how easily the heart moves about in it. Cut the pericardium along the anterior surface and observe the pericardial fluid. Compare the right and left sides of the heart. Observe a groove running obliquely along the anterior surface of the heart in which run blood-vessels often covered by fat. The part to the right of this groove is the *right ventricle;* the part to its left is the *left ventricle*. Press the two sides and note the difference in firmness. The ear-like appendages with notched margins at the base of the heart on each side are the right and left *auricles*. Compare the front and back surface of the heart. Identify the *pulmonary* artery, the *aorta* and its branches, and the *venæ cavæ*. Trace the branches of the pulmonary artery into the lungs. Observe the aorta with its arch, and the large vessels branching from the top of the arch.

4. If the heart be attached to the lungs it will be easy

to find the front of it. If the heart alone is obtained, its front may be determined:

(1.) By a groove filled with fat, the interventricular sulcus, which runs obliquely from the middle of the base of the ventricles to rather below the middle of the right margin of the heart.

(2.) By the anterior surface being more convex than the posterior.

(3.) By noticing that the right ventricle is much more yielding than the left.

(4.) By pouring water into either side of the heart and watching from what artery it issues. If it issues from the aorta, which may be easily known by being the large artery arising from the *center* of the base of the heart, it will be known that the water was poured into the left ventricle. But if it issues from the pulmonary artery, located at the base of the right ventricle between the two auricles, and farther from the center of the base than the aorta is located, it will be seen that the water has passed through the right ventricle.

(5.) By noticing the positions of the aorta and pulmonary artery, the latter being toward the front of the base of the heart.

5. Note the difference between the veins and arteries which communicate with the heart.

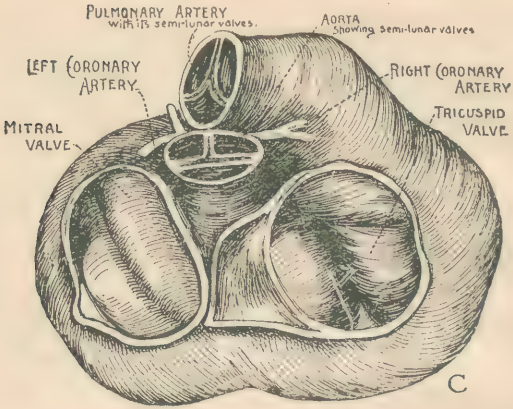
6. Examine the valves which will be found lying close against the walls of the right ventricle. Note the white

cords attached to the lower edges of these valves. How many flaps are there, and how are they arranged; how are they held in place; how are they acted upon; and how do they act?

7. Tie or hold a glass tube in the pulmonary artery just above the semi-lunar valves, and pour water into the tube. The fluid is prevented from entering the heart. Try the same experiment with the aorta. The semi-lunar valves of both these arteries are found just where they pass from the base of the heart.

8. Cut away most of the right auricle and pour some water suddenly into the auriculo-ventricular opening, noticing howthe tricuspid valves float up and close the opening. Lay the right ventricle open by a cut through the ventricle wall between two of the folds of the tricuspid valve, observe thin fibres, the *chordæ tendinæ*, attached to the folds of the valves, and to the projections of the inner surface of the ventricular wall, the *columnæ carneæ*, or muscular pillars. From the ventricle, make an incision upward so the semi-lunar valves of the pulmonary artery can be seen from below, and pour water into the pulmonary artery from above so the action or the valves can be seen from below. Make a similar examination of the left side of the heart.

9. Observe that the walls of the left ventrical are much thicker than those of the right.



A TOP VIEW OF THE HEART after the auricles have been cut away will show *tricuspid*, *mitral* and *semilunar* valves.

10. A transverse section of the heart just below the auriculo-ventricular valves shows the right ventricle as a split in the walls of the left.

11. A vertical section through the left ventricle shows how the walls of the ventricle grow thinner from the base to the apex of the heart.

12. Apply the ear to some person's chest, just over the heart, and note the *sound*. A simple stethoscope for auscultating one's own heart may be made by attaching a piece of rubber about twenty inches long to a small glass funnel.

13. On a bare chest between the fifth and sixth ribs, about two inches to the left of the sternum, the *impulse* of the heart can be felt, and by applying the fingers of the other hand to the radial artery, the interval of time between

the heart-impulse and the pulse-beat will give an idea of the rate at which the pulse-wave traverses the arterial system.

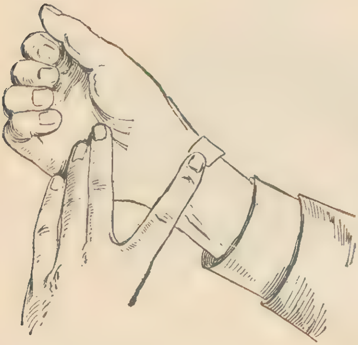
14. Examine the *location of arteries* in your own body,—

1. Feel the radial artery at the wrist.

2. Press on the temple and below the ear.

3. Place the hollow at the knee on the patella of the other leg. Watch the foot move. Feel for the artery back of the knee.

15. It may be demonstrated that the *movements of the artery*, as the pulse wave passes through it, consist of a sudden dilatation, followed by a slow contraction, interrupted by one or more secondary dilatations. To show this, get a piece of looking-glass about an inch square. Get some soft wax and make three balls, each about the size of a pea. Stick all of these on the back of the mirror so it will have three supports arranged in the form of a triangle. Push the sleeve back from the wrist, and place the little mirror so that one of the wax legs will rest on the radial artery, or "pulse." Now hold the wrist so the sun-light will fall upon the mirror, and watch the spot of reflected light thrown upon the wall. The mirror moves with the pulse, and the beam of reflection thrown on the wall moves with it. The movement of the artery is small, but the reflection on the wall moves over a space of several inches and we can see it plainly.



The experiment may be tried without the wax supports for the mirror, by simply placing it upon the radial artery in such a way that it will be slightly tilted with each pulse-beat.

16. Cut into a vein and examine its valves.

17. Tie a string around the forearm below the elbow, but not tight enough to stop the radial pulse and note how the veins become distended on the back of the hand. The little venous prominences, about an inch apart, indicate very nearly the position of the valves.

Prove that compression is injurious.

18. Make a powerful expiratory effort with the glottis closed. Notice the purple face and swollen veins of the neck. What is the cause? A sudden inspiration will draw the blood back into the thorax.

19. Why may a child's face "turn black" from crying?

20. Press on the skin of the arm. A white spot results. Why?

THE BLOOD.

21. With a moderately powerful microscope the *circulation of the blood* may be seen in the frog's foot. Split a shingle in the middle, cut a V-shaped notch at one end, wrap the frog in a wet cloth, with one leg projecting, tie it to the shingle and after tying threads around two of its longest toes, stretch the web, not too tightly, over the V-shaped notch. By elastic bands, fix the shingle upon the stage of the microscope, so as to bring the web of the foot under the object glass. Moisten the web occasionally with water.

22. *To see the corpuscles*, get a triangular piece of cover-glass a little smaller than web being examined. Place a small drop of water on one side of it and lay the glass with the water downwards on the web. Both kinds of corpuscles may be seen.

23. With a glass rod transfer a *small* drop of the frog's blood to a glass slide and place on it a cover-slip, running a little oil around the edge to prevent drying. Make drawings of the corpuscles seen.

24. Obtain a *small* drop of human blood by pricking the finger with a sharp needle. Examine as before. Notice how the red corpuscles roll about when the cover-slip is lightly touched. Soon after being taken from the body they stick to one another, and, owing to their shape, usually in rows.

25. Place a drop of fresh blood on a clean plate and watch it coagulate.

26. To show how blood holds a mineral substance in solution, place a piece of egg shell in vinegar, or dilute sulphuric acid. It will be dissolved.

27. If blood from a living body be injected into the veins of one that is very weak from the loss of blood, strength and new life will return. This operation, called transfusion, has been practiced upon man with success.

Some pupils have probably seen physicians inject medicine into the veins of their patients.

28. *Show the manner of treating cuts and bruises, and of stopping bleeding.* Let red pencil marks made on the face, arms, fingers, etc., stand for cuts. Apply suitable strips of plaster in a proper way for a great variety of imaginary cuts, After putting on the plaster, practice on bandaging the parts with strips of cotton cloth rolled for the purpose.

Practice on using the handkerchief for a variety of bandages.

29. *Show how to stop bleeding from the arteries.* Locate the principal arteries on your own person and that of a friend. Let red-crayon marks stand for the course of the arteries. Study this part of your anatomy thoroughly. Now and with strings, cords, shoestrings, handkerchiefs, elastics. strips of clothing, practice tying them so as to press deeply and firmly in the proper place. Let each one in the class

practice at the same time on the same artery. Criticise and improve each other's work.

30. *Effect of alcohol upon the blood corpuscles.*

If you should take a drop of blood upon your finger and put it under the microscope and then add a little alcohol to it, you would see that the corpuscles would be quickly destroyed. In a few seconds they would be so shriveled up that no one could tell that they had ever been the beautiful little corpuscles which are so necessary to health. When alcohol is taken as a drink, it does not destroy the corpuscles so quickly, but it injures them so that they are not able to do their work of absorbing and carrying oxygen well.

This is one reason why the faces of men who use alcoholic drinks often look so blue.

RESPIRATION.

1. *Observe* the arrangement of the ribs, cartilages and sternum in the thorax of a rabbit or some other animal.

Note the diaphragm and intercostal muscles.

Examine the structure of the trachea and larynx.

Place a tube into the trachea and inflate the lungs.

Observe the distribution of the pleura.

The pair of phrenic nerves going to the diaphragm may be seen as white threads running along on each side of the membranes which enclose the esophagus and blood-vessels.

2. Observe the action of cilia in the live frog's mouth, the motion being the reverse of that in the human trachea.

Hold a frog's mouth open, place a small moistened piece of paper or cork (smaller than a pin-head) on the roof of the mouth, and watch how it slowly moves down into the esophagus.

3. Measure around your chest after a forced expiration and inspiration.

4. Can you drown a grasshopper by holding its head under water? Watch a grasshopper breathe. Notice the breathing pores along the sides of the abdomen, in each segment.

5. Apply a drop of oil to the abdomen of a grasshopper or some other *insect* and it will fall dead at once, from suffocation.

The largest spiracle or breathing-pore, in insects, is usually found on the thorax. The *moth* may be strangled by pinching the thorax.

6. How does a fish breath?

7. Watch closely the frog's breathing.

1. Put pieces of paper over the nasal openings.

2. Watch movements in throat and sides.

3. Fasten the mouth open.

4. Hold the tongue outside of the mouth. The frog having no diaphragm and no ribs must use the mylo-hyoid

muscle in order to force air into the lungs, or to expel it from the nasal openings. Observe the two lobes of the frog's tongue, which serve as valves to the posterior nasal openings — thus controlling the ingress and egress of air.

8. Inflate the *lungs of a frog.* Observe that they are nearly hollow sacs, and not spongy all the way through as in the rabbit or man. When a lung has but few cells, only a small quantity of blood can come in contact with the air. Such a lung is adapted to an animal of low temperature and sluggish habits.

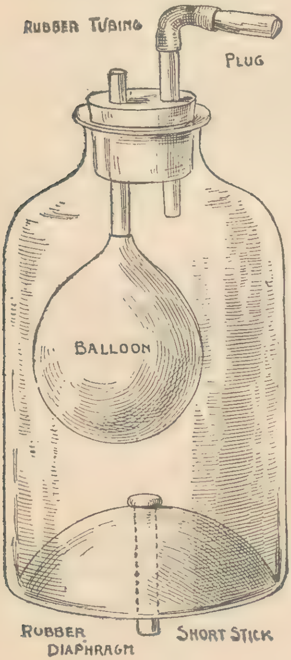
9, Part of the impure blood of the frog is sent to the skin through which it can get oxygen. How does the frog get oxygen when it is under water for a long time, or when it is in the mud during the winter?

10. *How the respiratory movements cause the air to enter lungs may be illustrated.* Cut off the bottom of a four-ounce bottle.

(The bottom, or neck, of a bottle may be broken off by winding a thick string around the place to be broken, saturating it in coal oil, turpentine, or alcohol, and setting it on fire. It may be necessary to plunge it suddenly into cold water to cause a fracture.)

File the cut edges mooth, and then over the end tie a piece of sheet rubber (such as dentists use) into the center of which a short stick has been attached by tying the rubber over a groove near the end. Make two holes through the cork and fit two short glass tubes in them so that the ends will protrude above and below. (Other tubes will serve.)

To one of the lower ends tie a small *rubber balloon*, or a *bladder*, and over upper end of the other tube fit a short piece of rubber, tubing, for which a plug has been made to close it.



Through the rubber tube suck part of the air from the bottle, causing the rubber diaphragm at the bottom to arch upward, and the balloon to be expanded. Now while the fingers hold the rubber tube to keep air from entering, place the plug in the end of it. Now, by pulling the rubber diaphragm down with the short stick at the bottom the balloon will be further expanded? Why? How do we get air into the lungs?

11. Breathing may be illustrated in a simpler manner as follows: —

A small lamp chimney is closed at the upper end by a stopper, through which is a perforation. A short tube extends half way through the stopper, and a small balloon, such as are sold at county fairs, which squeaks when blown into, is fastened to the lower end. The bottom of the chim-

ney is loosely covered with oil silk to represent the human diaphragm. When this is pushed upward, the balloon contracts, and when the oiled silk is pulled downward, the pseudo lungs inflate.

AIR.

Some of the *physical properties* of air may be easily shown.

1. The boy's "sucker" or leather weight lifter is easily made and illustrates in a forcible manner the downward pressure of the atmosphere. Take a piece of leather two or three inches in diameter (round or square) and attach a string to the center. Wet the leather thoroughly and press it firmly down on a smooth stone, piece of metal, or polished wood. The air is all excluded from between the leather and smooth surface, and the pressure of the air on the surface of the leather will cause it to adhere to the object. Quite a heavy weight may be lifted by pulling on the string.

2. Suck the air from the hollow stem of a key, and quickly press the end of the stem against the lip. It will be held there by the pressure of the air.

3. Take an ounce vial. Heat it carefully over a lamp, or by immersing in boiling water. Now press the mouth of it against the fleshy part of the hand, where it will be held by atmospheric pressure.

4. Place the mouth downward in a saucer of warm water. The pressure of the air will force the water into the vial,

5. Take a tumbler, fill it with water, place a piece of writing paper over the top, and invert it. The pressure of the air will prevent the water from flowing out. The paper prevents the air from forcing its way into the water, by rushing up along a part of the inner side of the tumbler, leaving the water to fall down on the opposite part. If the tumbler could be held steady the paper would not be required.

6. What would be the result if a small opening should be made in the bottom of the tumbler?

7. Place a thin green leaf over the lips and draw in the breath strongly. Why does the leaf break in with a snap?

8. Immerse a tumbler horizontally into a bowl of water, and press it down gradually. It will fill with water and afterward be entirely below the surface of the liquid. Now turn it to a vertical position, and without raising its mouth above the surface, lift it as high as possible. The whole tumbler is still filled with water, and will remain filled. The tumbler contains no air, while the air over the remaining water presses downward upon the water. This pressure of air supports the column of water in the tumbler.

9. Take any glass tube that is smooth and square at one end. Place the other end in water and press the thumb firmly over the smooth end. On lifting the tube vertically upward a portion of water will be held in the tube by atmospheric pressure so long as the thumb is kept tight. If the tube be large it will be difficult to hold the water in

as the least motion sideways will give the air below the advantage and a bubble will wedge its way up the side of the tube and a corresponding amount of water will fall out. If the tube be quite small the water may be easily retained. As soon, however, as the air is admitted at the top by removal of the thumb the water falls out. A small tube is thus made useful in dropping liquids.

10. Pupils have all noticed that molasses flow from a barrel better when the "air hole" is open.

11. Place one end of a piece of rubber tubing (two pieces of rye straw will do, if the one is fitted tightly into the other near the joint,) into a pail of water, and let the longer end hang over the edge of the pail, reaching below the bottom ot it. Suck some water through the tube. Water will flow out till the pail is empty. Why? What practical use may be made of the principle of the siphon.

12. The "Bottled Imps" or "Cartesian Devils" experiment may be performed in a very simple manner as follows: Fill a quinine bottle even full of water. Take a small homeopathic vial and fill with water until it will just float bottom upward in water. This may be determined by trial. A small amount of air will be in the vial. By pressing on the surface of the water in the quinine bottle with the palm of the hand the vial descends to the bottom and rises again when the hand is removed. The pressure on the water is transmitted to the air in the vial, which, being reduced in

volume, its specific gravity has lessened, and it sinks. The water will be seen to rise in the vial and the air space becomes less, and as the pressure is removed the opposite effect is observed.

13. Try the same experiment, by tying a thin piece of India rubber membrane over the mouth of a jar and pressing upon it.

14. Immerse an inverted tumbler perpendicularly in water. Only a very little of the water will enter the tumbler and of course the air in the tumbler is compressed. If the vessel is pressed down still farther a little more water enters it, but it will never be entirely filled with water, because it contains air. A cork previously placed in the tumbler will show the position of the water-level inside. Air maintains its place like every other body, and presses upon bodies. Its pressure is distinctly felt, and if you withdraw the hand which presses the tumbler down, the tumbler will instantly rise. The air in the glass was compressed, and tended to expand again, because air, like other bodies, is elastic.

15. Take a quinine bottle. Fill half full of water. Arrange two small tubes through the cork, one to dip beneath the water, the other to go a little way through the cork. Attach a rubber tube to the latter. Let the other tube be drawn to a fine point to make a jet. Blow with the mouth into the rubber tube. The air in the bottle will be compressed, and acting on the water will drive it up the other tube in a miniature fountain.

Composition of the Air,

16. Upon a cork, floating on water in a pan, place a small piece of phosphorus. [A piece as large as a grain of corn will do. *Be very careful in handling phosphorus. It should never be handled with the fingers,* and should be kept under water all the time, even while the piece for immediate use is being cut off.] After the phosphorus has become dry, ignite it with a hot wire, and immediately invert a large wide-mouthed glass jar over it in the water, holding it with the hand. Watch the dense fumes. After the phosphorus has burned away, the fumes will be absorbed by the water. It will be seen that the water rises to occupy the place vacated by the oxygen which unites with the phosphorus. What part of the space in the jar does it occupy? Slip a glass plate under the mouth of the jar and place it mouth upward without admitting any air. Lower a lighted splinter into it. Why will it not burn? What is the use of nitrogen in the air?

17. Heat a few pieces of potassium chlorate in a test tube. The salt first crackles, then melts and boils from escape of oxygen gas. Test for oxygen in the tube by lighting a match, and, after letting it burn for a few seconds, blowing it out, and introducing the red-hot tip into the mouth of the test-tube. The match bursts into a flame. Oxygen is the great supporter of combustion.

18. Enough oxygen for experiments may be made by

placing into a large test-tube a teaspoonful each of pulverized potassium chlorate and manganese dioxide. Attach a tube about a foot or more in length, the free end to dip betheneath the surface of water in a large pan. Apply heat to the test-tube by means of a spirit lamp.

(*A Spirit Lamp* may be made by coiling a piece of tin around a lead pencil so as to form a tube obout two inches in length, this tube to be put through a cork which when fitted tightly in a bottle and provided with a wick completes the lamp. A cap may be made by hollowing a piece of cork. This should be put over the tube when not in use to keep the alcohol from evaporating.)

Read the Caution Below.

To catch the gas, the end of the tube leading from the generator is placed under the water in the pan, furnished with a perforated shelf just beneath the water level. The jar, or other vessel to be filled with the gas, is first filled with water and inverted over the hole in the shelf. So long as the mouth of the jar is beneath the water, the pressure of the air will sustain the water in the jar. The gas passes through the tube from the generator and bubbles up through the hole in the shelf into the jar while the water sinks down. When the jar is full it may be removed and another filled in the same manner. A tub or pail will answer instead of a pan. In place of a shelf two bricks laid about an inch apart in the bottom will answer admirably.

The jar can be set over the space between them, the edge of its mouth resting on each brick. If the pupil has an assistant who will hold the jar in his hand the shelf is not necessary. It will be convenient to have the pan deep enough to fill the jars by immersion.

A jar which has been filled with gas may be removed from the pan by passing a plate or saucer beneath its mouth and removing plate and jar and leaving a sufficient amount of water to cover the edge of the jar. The gas can be kept in this way until wanted.

Caution. Allow the first portions of gas to escape. Remove the tube from the pan before the fire is removed, as, otherwise, the cooling of the test tube will condense the gas and the partial vacuum will be filled with water from the pan and this water being suddenly converted into steam will cause an explosion.

Glass or copper retorts are commonly used in preparing oxygen when wanted in considerable quanities, but sufficient for purpose of testing its properties can be made with a test-tube. Large stoneware ink bottles may be used for retorts but they are liable to break if not heated properly.

19. Fill a quinine bottle with oxygen. Ignite a piece of charcoal and lower it on a wire into the bottle. It burns with beautiful scintillations. If the piece of charcoal be large enough, all the oxygen will be "burned out" and carbon dioxide (CO_2), commonly called carbonic acid, form-

ed by the combustion, will fill the bottle. Does it support combustion?

20. Show that oxygen will combine with iron. Take a piece of broom wire, or some of the fine wire used by florists. (Picture wire, or a watch-spring, heated to take out the temper, wil ldo.) Make half of the wire into a spiral by wrapping it on a lead pencil. It is better to have the coil end hammered very thin. Push the straight end through a piece of pasteboard. After holding the coiled end in a flamefor an instant, dip it into sulphur. Enough will adhere to be set on fire by holding it in the flame again. Then at once dip it into a wide-mouthed bottle of oxygen, with a little water in the bottom to prevent the bottle being broken by the hot drops of *iron oxide* which fall from the burning wire.

21. Shake up some lime with water in a bottle, and after allowing it to stand, pour off the lime water to use as a test for *carbon dioxide*. Catch some of the gas from the top of the lamp flame and test it with the lime water to show that it contains carbon dioxide.

22. By breathing through a tube into a glass containing lime water show that the respired air contains carbon dioxide.

23. Make some carbon dioxide by ponring some hydrochloric acid on some limestone rocks in the bottom of a glass vessel. Test with the lime water.

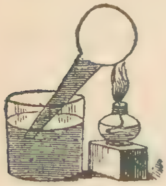
24. By breathing on a cold glass, show that the respired air contains water.

25. Hold a cold plate over a burning lamp.

26. Fill a candy jar with water, so that the air is expelled, and hold it with the mouth inverted in water. Place one end of a tube under the mouth of the jar, and the other end in your mouth; exhale through the tube the air from the lungs, without inhaling through the nose. When the jar contains no more water, the air from the lungs having taken its place, place the hand or a piece of heavy paper over the mouth, and turn the jar upright. Fasten a piece of candle to a wire. Light it and immerse it in the jar filled with the exhalations of the lungs. The flame will instantly expire. The reason of its going out is, that the jar is filled with carbonic acid gas, a deadly poison. This experiment teaches a very impressive lesson on ventilation. The same carbonic acid gas which has been exhaled into the jar, is being constantly breathed in unventilated rooms, bedrooms, schoolrooms, halls, churches, etc., and the effects are most pernicious. Life expires as the lighted candle, not as suddenly always but as surely.

VENTILATION.

1. When a kettle, etc., full of cold water, is set on the fire, before it boils some of the water is sure to run over, when the kettle is said to *boil over*.



2. Take a flask or thin bottle with a rather long neck, and put in a little water, about enough to fill the neck. Then keeping this water in, fix or hold it with the mouth just below the surface of a glass of water. The neck will be filled with water and the rest with air. Now bring the flame of a lamp, or any anything hot, near the flask, and the water will go down in the neck; withdraw it, and the water will rise again. Even putting a warm hand on the flask will make a difference; and on the contrary, if anything very cold is brought near the flask, the water rises, and falls again on its being taken away. Again, take the empty flask (or bottle), heat it, and turn it at once into the glass of water as before. The water will begin to rise in the neck, and fill the flask more or less, according as it was more or less heated. (But it must not be heated too much, or the cold water rising intc it will crack it. Why?)

The water in the first case gets too much for the kettle to hold; and other liquids tried in a similar way, in vessels of a suitable sort, do the same; so that liquids also are expanded by heat. The second shows that air also and other gases are expanded by heat. It will be noticed that a much greater difference is made in the bulk of the air, and more quickly, than in the case of either solids or liquids; and hence it follows that gases are much more *readily* expanded than either solids or liquids. This expansion is the reason

of the currents which heat causes in fluids. Their particles don't hold together, so as to prevent their moving over one another. Those who receive heat are expanded; their size is increased, but no weight added to them; they get bulk for bulk *lighter* than the colder parts, and therefore *rise*. Colder parts move in to fill their place, get expanded in their turn, and so on.

This is one cause of the winds, for the sun heats the earth more in some parts than in others. From the former the hot air rises; and from the latter the cold air rushes in to take its place. This is the great means of carrying off the excess of the sun's heat from the hotter parts of the Earth, which but for this would be all desert. It is on this principle, too, that all *ventilation*, natural and artificial, depends. Air is spoiled—rendered unfit for breathing—by animals breathing it, or by lights, etc., burning in it. This bad air is heated and rises, so that in the open air it is perfectly got rid of. But in a house it collects at the ceiling, and some escape ought to be provided for it there. Whatever does so is a *ventilator*. It is sometimes a perforated plate, or brick, or stone, let into the wall; sometimes a valve opening into the chimney near the ceiling; sometimes a pane of glass in the window, with holes, or opening on a pivot. In these cases the ventilation is briskest when there are openings on opposite sides of a room, for then the wind helps greatly by entering at one side to expel the bad air at the other. An open fire

and chimney give powerful ventilation. The chimney contains a column of air, and when there is no fire this column is usually about the same temperature as the rest of the air, and has little tendency to move. Even when a fire is first kindled it is the same, and hence the smoke often comes out into the room. But soon hot air, gases, and smoke from the fuel begin to fill the chimney, and it becomes a column of *hot* air, which is lighter than the colder air above, and rises. Cold air passes in at the grate to take its place, and a *draught* is established. Now, consider that every foot of heated air has a certain floating power, or force, to rise in the chimney, and that the more we have of them, the greater must be the force of the whole. Hence we see why a longer chimney gives a more powerful draught. Again, our fire-places are generally wide, in order to allow heat to radiate as widely as possible. Hence, besides the heated gases from the fire, a great deal of air is drawn in and enters the chimney *above* the fire. This air is colder, and renders the column less buoyant. Hence we see why a *blower*, or metal screen, covering up the front of a grate down to the bars, increases the draught and makes the fire soon roar up. No air goes up the chimney but what has passed through the hot fuel. So the column is much lighter, has greater floating or upward force, and rises faster. Air is then drawn in faster to supply its place, and hence the fire burns faster. In boiler furnaces there is little or no opening at the doors, but the air has to pass up

between the bars on which the fuel lies, and through the burning fuel, before getting to the chimney. In the chimney, near the bottom, there is generally the *damper*—an iron plate, which either by sliding out and in, or by turning on pivots, can be made to close up the chimney more or less, or leave it quite open. By this the fire can be *regulated* to a nicety; for the more it is closed, the less rapidly can the draught pass, the less rapidly is air drawn in at the bars, and therefore the less rapidly does the fire burn. The chief defect of an open fire as a ventilator is, that since our fire-places are near the floor, the air carried up the chimney is not drawn from near the ceiling, where the worst air gathers, but from below. This defect may be remedied by a valve placed in the wall near the ceiling, and opening into the chimney.

3. Open upper and lower sash of the window two inches, and test the direction of the currents with a torch of cotton wet with alcohol.

4. Hold a candle flame at a room door standing ajar—first, near the bottom; second, at the middle, third, near the top. Explain the difference you observe.

5. How is a coal-mine ventilated when there are two shafts? How, when there is only one shaft?

6. Describe some simple arrangements you have seen for ventilating and warming a building.

7. In halls, churches, and theatres, do the galleries or floor get the worst air? Why?

8. Tell some advantage in having a high ceiling to a room.

9. How do currents of air go in a room with one window opened — 1st, when there is a fire; 2d, when there is no fire?

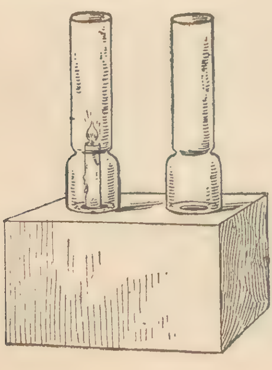
10. In the bottom of a common plate place vertically a short piece of candle. Light it and after placing a wide cyclindrical lamp-chimney over it, pour water into the plate to keep the air from entering at the bottom. What effect onthe flame?

11. Cover the lighted candle with the wide chimney as in the last experiment, and, after pouring water in the plate, place a thin cardboard partition in the chimney, reaching nearly to the flame. Notice the effect.

Hold a piece of burning touch paper over the top of the chimney and study the air circulation.

(Touch paper is made of soaking pourous paper in a solution of salt petre and then drying thoroughly. It gives out considerable smoke in burning.)

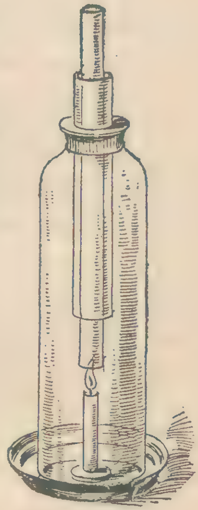
12. Get a common chalk-box and paste paper over the cracker to make it air tight. Make some small holes in a circle



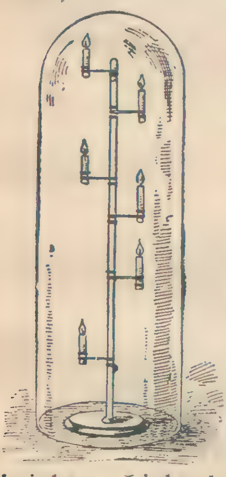
near one end of the cover, watching to make the circle somewhat smaller than the base of a lamp-chimney. In the center of the circle stand a short lighted candle and cover it and the openings over with an Argand lamp-chimney, such as can be purchased at nearly any drug store. Near the other end of the cover cut a hole nearly an inch in diameter,

and cover it with another chimney. Coat the lower edge of each chimney with paraffine or wax to make an air-tight joint. Now hold burning touch-paper over the tops of the chimneys and study the air currents.

Close the top of the chimney which does not contain the candle, and notice the effect.



13. Into a tall wide-mouthed jar or bottle, with the bottom broken away, fit a cork through which can be inserted a wide cylindrical glass chimney (or a wide paper cylinder). Place the jar over a candle standing in a plate of water. Observe the effect on the flame, as in the last experiment, then insert into the chimney a smaller glass tube, or paper cylinder, letting it extend nearly down to the flame. Put lighted touch-paper at the top and study the air-current.



14. Support perpendicularly a small stick, fifteen inches high, and invert a tall jar over it. By means of small wires which can be wound around the stick, support small pieces of candle at different heights. Light the candles, and with the jar inverted over

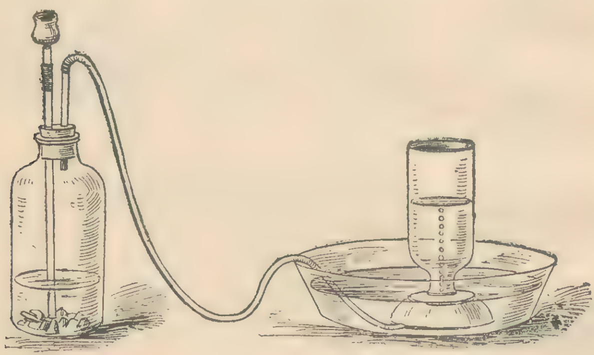
them, observe the order in which they are extinguished. Which ones go out first? Why?

15. Test different parts of the school-room for carbonic acid.

COMBUSTION.

Several of the experiments given illustrated *chemical action*. Others which are instructive may be given.

1. Get a wide-mouth bottle, some wider than a quinine bottle. Insert two glass tubes through holes in the cork, one of which should extend nearly to the bottom of the bottle and have a small glass funnel placed in it at the top. The other should just pass through the cork below, while to the end above the cork should be attached a piece of rubber tubing long enough to reach beneath a tin pan inverted in a large pan of water near by.



The tin pan should have a notch in one edge so the tube

ing can pass under freely and should have a hole in the middle of the top over which a quinine bottle filled with water may be inverted.

Place small clippings of sheet zinc into the bottom of the bottle, and pour in water until it is about one-fourth full. Now fit the cork into the bottle, and *see that all of the joints about the mouth of the bottle are tight.*

Pour some sulphuric acid, (or hydrochloric) through the funnel tube, about a thimble full at a time. Hydrogen is formed at once, passes out through the rubber tubing and displaces the water in the inverted bottle. Why? The first gas generated is *dangerously explosive* and should be thrown away. Feel the bottle. Why is it warm? *Several instructive experiments may be made with the hydrogen.*

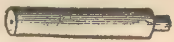
2. After the quinine bottle is full of the gas, bubbles of it will escape through the water. Bring a lighted splinter to the water where they are escaping. Is there an explosion?

3. Raise the bottle of gas from the pan, keeping it inverted. Insert a burning splinter up through the mouth of it. Does the gas burn? If so, where?

4. Light another splinter, and bring it to the mouth of the bottle while it is being inclined. The explosion is caused by the oxygen of the air uniting with the hydrogen to form water.

5. Hydrogen is most conveniently prepared by placing a small handful of nails or iron scraps in a sarsaparilla bottle, and pouring sulphuric acid, diluted with about twice its weight of water, over the nails in the bottle, until they are covered with acid. The hydrogen will be given off in a few minutes. A cork with a small glass or tin tube in it can be fitted to the mouth of the bottle, through which the gas will escape. *Do not light the gas till the air is expelled, otherwise you will have a dangerous explosion.*

6. Hydrogen Gun.—Get a tinsmith to make a tube about seven inches long, and two inches in diameter. Have it closed at one end and open at the other, with a mouth large enough that an ordinary quart bottle cork will fit it. At the other end have a hole



about the size of a pin's head. Fill the gun about half with hydrogen and the other half with air. Hold a lighted match to the hole. You will get a report almost as loud as that of a pistol. If a cork is fitted to the gun, it will fly to the farther end of the room. The hydrogen gun can be held over the bottle, from which the hydrogen escapes, and thus be filled sufficiently for shooting.

7. Singing Tube. Get a glass tube, five-eighths of an inch in diameter, and hold it over the hydrogen flame, produced at the end of an eighth inch tube. A noise similar to that produced by a steam whistle will be produced.

8. Hold a small wire in the hydrogen flame. It will soon become red-hot.

9. Mix a little sulphuric acid (vitriol) in a test-tube or other thin glass vessel, with about half as much water. Find, by touching the bottle you get the acid out of, and by dipping the finger in the water, that both are quite cold ; yet on taking hold of the vessel in which they are mixed, the mixture will be found to be quite hot.

10. Fill a small tin vessel with quicklime, and pour on water. It will soon be too hot to hold, though neither the lime nor the water were hot separately.

11. Ricks of hay, barley, etc., sometimes get hot and brown, or even take fire, of themselves.

The lime and water, in the above experiments, make noise and fumes, showing they are violently acting on each other. The acid and water, if carefully looked at and measured, will be found to have ve shrunk ; that is, they do not take up quite so much space mixed as they did separatly. The heating of ricks generally happens when they are put up damp. Wet causes hay to ferment ; and an instrument has been invented to prevent it, by cutting a hole to let the air into it. In each case, then, we have two bodies acting on each other ; and as chemistry treats of the action of two bodies on each other, we may call these cases of *chemical heat*. In the same way, oily cotton-waste, or wool lying in heaps, has been known to get heated and take fire, and factories have been burned in consequence. Such are sometimes called cases of *spontaneous combustion*.

12. To a teaspoonful of powdered sugar, add a few drops of sulphuric acid. Notice that the sugar puffs up and becomes a mass of black, porous charcoal. Explain.

13. Pulverize separately a teaspoonful each of loaf sugar and potassium chlorate. Mix them together, without rubbing, on a piece of a common plate. Carefully let one

drop of sulphuric acid fall on the mixture. Observe the violent combustion. The potassium chlorate contains much oxygen, which unites with the carbon of the sugar.

14. On a piece of paper place a piece of potassium chlorate the size of a pea, and cover it with powdered sulphur. Wrap them tightly in the paper so as to form torpedo. Place on a smooth rock and strike a blow with the hammer. What causes the explosion?

15. Pour a few drops of nitric acid upon a copper cent. Watch the action.

ANIMAL HEAT

And the Thermometer.

In all the organs of animals, oxidation, or burning of organic matter derived from the food, is going on. The oxygen is taken into the blood, through the lungs, and is evenly distributed to all parts of the body.

1. It may be seen that an animal breathes faster when at work. It requires more oxygen, and consumes more of the organic tissue than when at rest.

2. The boy has noticed that running or working makes him warmer. The heat of the body has been increased by increased oxidation.

In all animals in a state of health, the heat-producing and heat-destroying processes balance each other, and a standard temperature is obtained. The mean temperature of some birds is 111° F., but in man, is about 98.6°. Some of the pupils have probably learned from experience in cases of sickness that temperatures below 97° or above 106° F. are extremely dangerous to life. Parts which have the greatest extent of surface in proportion to their bulk cool off most rapidly, and some of the projecting portions of the body are constantly cooled below the normal temperature of the blood and internal organs. All have noticed the effect of a cold day upon the fingers and ears.

The Thermometer.

3. Perhaps it maybe profitable at this place to introduce a discussion of the physical principles, upon which the construction of thermometers depends.

It may be shown that both the making and the use of the thermometer depend on the expansion of liquids and gases.

Mercury is the liquid generally used, as it expands most equally, and is liquid at all ordinary temperatures. The tube is sometimes filled by heating the empty bulb over a lamp till the air within it is very much expanded. The open end is then dipped into a vessel of mercury, and the air contracting draws the mercury after it. Enough is put in to fill the bulb, and it is again heated till the mercury rises to the top of the tube, which is then rapidly melted, and thus entirely sealed up. It is now necessary to graduate it, or divide it off into degrees. For this purpose, two points are found, which are the same for all thermometers—first, the temperature for melting ice or snow; and second, that of boiling water. The bulb and most of the tube is first placed into melting ice, and the point at which the mercury settles carefully marked. It is then enclosed in a vessel (see figure) in which the water is boiled, so that the bulb is a little *above* the surface of the boiling water, and the whole of it kept surrounded by steam. The point to which the mercury rises is again carefully marked. The space between these two points is, in England and the United States, still usually divided into 180 degrees—the freezing-point being numbered 32°, and the boiling-point 212°, as shown in Fig. 14, on the left side. This arose from the inventor, Fahrenheit, knowing that a mixture of salt and snow was colder than ice, but not knowing anything colder, or, according to others, meet-

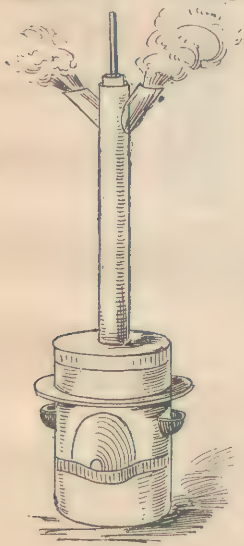


FIG. 13.

ing with that degree of winter cold in Iceland, and making that his starting-point, *zero*, or 0°. The Fig. on the right shows the *Centigrade* or French method of calling the freezing-point 0°, and dividing the length above, up to the boiling-point, into 100°. Another division, used in Germany and Russia, in which the freezing-point is 0° and the boiling-point of water 80°, is shown on the right of Fig. 14. Spirit of wine (alcohol) is sometimes used instead of mercury. There is an advantage in this, when the temperature to be measured may fall to 39° below zero of Fahrenheit's thermometer, for then mercury freezes, while spirit of wine has never been known to freeze. There is an advantage in alcohol, also, when very slight changes are to be noted. All liquids are not equally expanded by the same heat; and spirit of wine is found to expand six times as much as mercury. Hence each degree as marked on a spirit thermometer is six times as long as it would be on a mercury thermometer of exactly the same size of bulb and tube. Thus, on the spirit thermometer small changes, say of quarter or half a degree, are more readily and quickly seen. This is expressed by saying, it is *more sensitive*. But as the spirit boils at 173°, it is useless for measuring degrees above that; while the mercury might be used up to 600°, if made with a long enough tube. Hence a mercury thermometer can measure a greater difference of temperatures than a spirit one; and this expressed by saying it has the *greater range*. In making thermometers, the tube is made longer or shorter, according to the *range* wanted of it. The very same range of tube is divided into (212–32), or 180 Fahrenheit, or into 100 Centigrade degrees, and 180 : 100 : : 9 : 5. Hence temperatures in degrees Centigrade may be reduced to degrees Fahrenheit

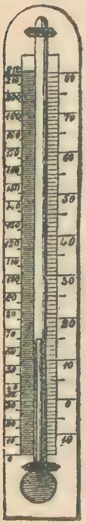


FIG. 14.

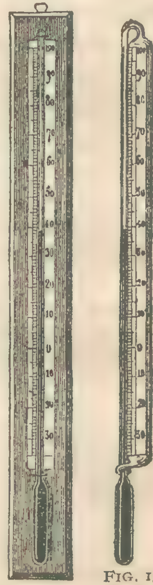


FIG. 15.

by the following rule: Multiply by 9, divide by 5, and add 32. Thus, to find the degrees Fahrenheit corresponding to 40° Centigrade:

$$\begin{array}{r} 40 \\ \underline{9} \\ 5)\ \underline{360} \\ 72 \\ 32 \end{array}$$

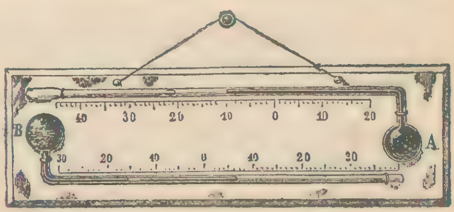
104° Fahrenheit.

To reduce degrees Fahrenheit to degrees Centigrade, reverse the above rule, substract 32, multiply by 5, and then divide by 9. Thus, to find the degrees Centigrade corresponding to 600° Fahrenheit:

$$\begin{array}{r} 600 \\ 32 \\ \hline 568 \\ 5 \\ \hline 9)\ \underline{2840} \end{array}$$

$315\frac{5}{9}^\circ$ Centigrade.

Degrees Fahrenheit and Centigrade are distinguished by the first letters, F. and C.; as 600° F., 315° C. Degrees *below* 0° of either thermometer are marked by the sign — (*minus*). Thus, — 12° F. means twelve degrees below zero, of Fahrenheit's thermometer; —30° C. means thirty degrees below zero, Centigrade; or, since zero and freezing-point Centigrade are alike, we might say, thirty degrees Centigrade below freezing. In referring to the ordinary or Fahrenheit scale, however, we must be careful not to confound zero and freezing, for they mean different things; and we must equally avoid the absurd expression, "degrees of cold."



A Maximum Thermometer (A, Fig.) is constructed to show the highest temperature it has reached.

It has a small steel wire or bead enclosed in the tube, and this is pushed along by the mercury and left at the farthest limit it reaches. A Minimum Thermometer (B. Fig.) similarly has a small glass or enamel stalk with beads or heads at each end. Alcohol is used in it, and, when expanding, readily makes its way past the glass or enamel; but, on returning, clings to it, and draws it with it, thus leaving it at the point reached nearest the bulb, and marking its lowest temperature. Both are set horizontally when used.

4. Get a physician's thermometer, and take your temperature, by putting it under tongue, closing the mouth tightly, and holding it there for five minutes.

5. Take the temperature at different times. It will be found nearly constant, and in the mouth, will be about 99° F.

6. Pour some *alcohol*, *ether*, or *carbon disulphide* upon the hand, and notice the cooling effect of the evaporation of moisture from the skin. Of what importance is *sweatin* when the temperature is elevated by fever?

7. Wave the hand in the air and notice that it becomes cooler because evaporation occurs more rapidly.

8. Notice that a dog perspires very little. How do they *cool off?* Is there any evaporation from the tongue while they are "*panting?*"

THE LARYNX AND VOICE.

1. Get from the butcher an unmutilated larynx of the ox, instructing him to leave the hyoid bone and tongue attached.

2. Examine the different cartilages, and the muscles that move them.

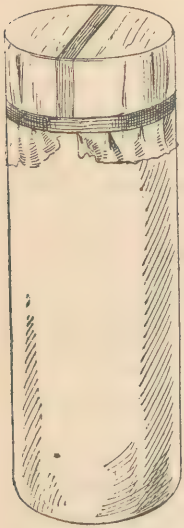
Notice the position and action of the epiglottis.

3. Cut the larynx open on the esophageal side. In the interior, from above downward, note :—

1. The mucus on the surface.
2. The two contiguous surfaces forming the upper slit.
3. The ventricles of the larynx, and
4. Two thin contiguous surfaces forming the *true vocal cords.*

4. To show the *action of the vocal cords* in the production of the voice, get a glass or wooden tube, and a strip of rubber such as dentists use in filling teeth. Wrap the rubber around the end of the tube, so that two edges of the rubber will come near each other in covering the opening, leaving a narrow slit between, (an Argand lamp-chimney will serve for a tube. It can be obtained at the drug store, and is very useful for many other experiments). Now by blowing into the other end of the tube the edges of the rubber bands vibrate. Touch the rubber membrane at different places while it is vibrating. The tone changes, the pitch depending upon the length and breadth of the vibrating part of the rubber membrane.

In the above experiment two pieces of rubber can be used instead of one.



5. Place the fingers on the larynx, and notice that it is drawn upward in making a note of a high pitch. High notes in the larynx excite vibrations in the air-cavities of the head, while low notes excite vibrations of air in the lungs. While singing a low note place the hand over the upper part of the chest, and the thrill communicated to the hand by the chest-tones will be distinctly felt.

6. By the means of the piano illustrate the production of the various vowel-sounds by the combination of tones resulting from the resonance of the air in the mouth. Raise the cover of the piano, depress the loud pedal so all the wires may vibrate freely, and sing a vowel-sound with a loud voice near the instrument. When the voice ceases, the piano will continue to resound with the note on which the vowel was sung, returning to the ear the particular vowel,sound which was uttered.

7. To show that the fundamental notes of the vowels vary in pitch, *whisper* the vowel sounds in the following words in the order given: *Rule, pole, far, fate, meet.* It will be seen that the pitch of the whispered sound rises in the order inwhich the vowel-sounds are given.

8. Observe the positions of different parts of the mouth which different vowel-sounds are uttered.

Notice that when the mouth is opened widely, while the air is escaping from the lungs, the sound made will be that of *a* in *far*. By bringing the lips gradually nearer, the sound will change to that of *o* in *pole*, and then to that of *u* in *rule*.

By keeping the lips open, and gradually raising the tongue so the back part of the mouth is narrowed, the sound will change to that of *a* in *fate*, and then to that of *e* in *meet*.

9. To show that these vowel-sounds are produced by the *varying vibration of the air* in the mouth, and not by the action of the vocal cords, place the mouth in proper shape for uttering any sound, as *a* or *o*, and without allowing any air to pass from the lungs, cause the air in the mouth to vibrate by sounding a jews-harp in front of it. The sound of the jews-harp will approach that of the vowel for which the mouth is fixed.

10. Notice the parts of the mouth used in making the different consonants.

11. It will be noticed that women and children have voices of a higher pitch than men. This is because their vocal cords are relatively shorter.

12. The members of the class have probably noticed the "break" or change in the voice of boys at about the age of 14 or 16. Explain that it is caused by a sudden growth or enlargement of the larynx, and the consequent increase in the length of the vocal cords. No such change takes place

in the larynxes of girls; therefore their voices undergo no sudden change.

THE SKIN.

1. With a hand lens compare the surface of the back of the hand with that of the palm. Along the ridges on the palm of the hand find the opening ducts of the sweat glands, which appear as little pits.

2. Place the hand in a dry glass jar, and with a cloth close the mouth around the arm. Moisture forms on the sides of the jar. Inference.

3. To show the cooling effect of evaporation, put a drop of gasoline, ether or warm water on the back of the hand.

4. Observe the modifications which epidermis may undergo, by examining hairs, claws, hoofs, and feathers of the common animals to be found near the school.

5. Burns.—Have a small quanity of soda, sweet-oil, and lime-water in the school-room. Imagine a pupil has burned his arm or hand. Show exactly what is to be done, and how.

NERVOUS SYSTEM.

1. Cut through the skin of a rabbit along the middle of the back from the nose to the tail, and strip it back towards the sides. Take away the muscles from the back of the head and fore part of the neck.

(1.) Between the skull and the atlas the *spinal cord* may be seen.

(2.) Insert one blade of the forceps up the side to the entrance of the spinal cord into the skull and cautiously cut and break away the whole roof of the skull. Observe the *dura mater*.

(3.) Note the shape of the *cerebrum* and its surface.

(4.) Notice the *olfactory lobes* protruding between the eyes.

(5.) Observe the *cerebellum* back of the cerebrum and also the *medulla oblongata*.

(6.) Cut through the olfactory lobes at the front of the cerebral hemispheres and carefully pry up the front end of the cerebrum. Running forward from the base of the brain will be seen the *optic nerves*, which join each other on their course from the eye to the brain.

(7.) Back of the optic nerves are the small *third* and *fourth* pairs, and the larger *fifth*, the small *sixth*, and close together the *seventh*, the *facial*, and *eighth*, or *auditory*, and farther back four more pairs.

(8.) Cut away the muscle along the backbone and remove the vertebræ carefully. Notice the variations in the diameter of the spinal cord in the course.

(9.) Observe the spinal nerves passing off in pairs through the space between the arches of the vertebræ.

(10.) Compare the color of the brain with that of the spinal cord.

(11.) Make a drawing of the brain and spinal cord.

2. Distinguish voluntary from reflex actions in the motions of a person.

3. *Show reflex action by experiments on the frog.*—By bending the head, find the joint between the head and backbone of a live frog. Place the frog on a board, and completely sever the spinal column and the spinal cord, by quickly thrusting a knife-blade through the body at this joint. Run a wire into the brain cavity and stir it about in order to entirely destroy the brain.

We may now be quite sure the movements which take place in the following experiments do not depend upon the brain.

4. Place the frog with its feet on the floor. Notice that its hind-legs are drawn up under the body; but it differs from the normal frog in several respects:

(1.) Its head is depressed, instead of being erect.

(2.) Its forelimbs are spread out, or flexed, instead of being held nearly vertical, and thus the front of the body comes nearer the floor.

(3.) There are no respiratory movements, either of the nostrils, or of the throat.

5. Touch it behind with a straw, or stick it with a pin. Can it jump?

6. Gently extend one of the hind-legs, until nearly straight. At first, perhaps, it will remain motionless, ex-

cept that the heart will continue to beat, but after the shock of the operation has passed away, its legs will be drawn back to its old position under the body. If much blood has been lost, the leg will be drawn up slowly.

7. Gently tickle one flank with a feather or a blunt pin, and notice the contraction of the flank muscles of that side.

8. Pinch the same flank sharply with a pair of forceps; the leg of that side will be extended, and then drawn up, and swept over the flank, the motion tending to strike at the forceps.

9. Pinch the skin at the rear of the spinal column. Both legs may be made to draw up and then be thrust out again.

10. Leave the frog undisturbed for a few minutes. It remains motionless.

11. Look for the automatic action of the posterior lymph hearts which areon either side near the hip joints. The contractions are generally visible through the skin.

12. Place it on its back; it makes no effort to regain its normal position. All sense of equilibrium has been lost.

13. Hang the frog by a string attached to the jaw.

Pinch the toes with a forceps and note the result. Will the leg be drawn up without any external stimulus?

14. Now scratch one side of the body with a needle. Pinch one side of the body again. Note the result in each case.

15. Get a glass of *dilute* sulphuric acid and place it so the tip of one of the toes just touches the acid. In a short time the foot is pulled away. Dip the toe at once into some water to wash away the acid.

16. Upon the flank place a bit of blotting paper moistened with strong vinegar, and watch the leg of the same side quickly move about as if to rub it off. If the leg now be held so it cannot move, the leg of the opposite side will try to rub off the piece of paper. Vary the experiment by placing the same paper on other parts of the body.

17. Now wash the vinegar from the frog, and place it in water. Can it swim? In most cases it will sink to the bottom and not move. If the lungs be accidentally much distended with air it will not sink.

18. Cut through the skin along the back side of the thigh; tear the muscles apart and sever the sciatic nerve, watching the foot at the same time.

19. Pinch the toes of each foot as before, and note the difference.

20. Alternately pinch the two ends of the severed nerve. What occurs?

21. Destroy the spinal cord by running a wire down the spinal column, and twisting it about.

22. Pinch the toes as before. Do they move now?

23. Again pinch the end of the sciatic nerve connected with the parts below, pinching a little lower than before.

24. Immediately beneath the skin of the back of the frog is the dorsal lymphatic sac, and any fluid placed in this rapidly makes its way into the blood. Before destroying the spinal cord, if we had cut through the skin of the back, and through a fine glass tube injected one drop of strychnia solution, in a few minutes violent spasms could have been produced by the slightest touch applied to any part of the animal. The spasms would cease on destroying the spinal cord.

25. Remove the heart of the frog and notice the *automatic action*. If it be kept warm, it will beat after being taken from the body.

26. Observe the *automatic action* of cilia. To do this, place the frog on its back, cut through the lower jaw in the middle line, and continue the incision down the esophagus to the stomach. Pin the parts back, and if the mucous membrane is not moist, place some salty water upon it. Now, on the upper part, place a *small, thin* piece of cork. It will be driven by ciliary action towards the stomach.

TOUCH.

1. Test the sensitiveness of the skin at different parts of the body by applying the points of a pair of compasses lightly, and observing how close they may be placed and two distinct sensations be felt. The tip of the tongue is most sensitive.

2. Notice that light pressure gives a clearer sensation than heavy pressure.

3. Place two light weights, one cold, the other warm, on corresponding fingers of the hands; the cold one will feel the heavier.

4. Cross the middle finger over the fore-finger and shut the eyes. Hold a marble between the tips of the crossed fingers. There seem to be two marbles.

TASTE.

1. Wipe the tongue dry and place dry quinine or sugar upon it. It will produce no taste. Why?

2. With a small brush test different parts of the tongue with small amounts of bitter, sweet, sour and alkaline substances to determine where each is best distinguished. Rinse the mouth after each test.

3. Close the nose, and with the eyes shut, place in the mouth a piece of onion. Its "taste" cannot be distinguished until the nose is opened.

4. Put a drop of vinegar on the tongue and notice how the papilæ of the tongue start up.

5. Light helps the sense of taste.

Pinch the nose, close the eyes, and see how palatable a teaspoonful of cod lives oil becomes.

THE EYE.

1. Select a boy having a prominent eye and a large ocular fissure. Have the pupils to observe:

1. The *eyebrows*.

(1.) Direction of the hair.

(2.) Thickness.

(3.) Hairless tract above bridge of nose.

2. *Eyelids*.

(1.) Junction of mucous membrane and skin.

(2.) Fifteen or twenty openings on the edge of the lower lid.

(3.) Slight elevation near the inner angle of the lower lid. By pulling the lid down, the small opening into the nasal duct may be seen.

3. *Eyelashes*.

(1.) Method of insertion.

(2.) Direction and curvature of upper and lower rows.

(3.) Non-interlacement.

4. *Conjunctiva*.

(1.) Color and thickness.

(2.) The tarsal cartilage pressing on the conjunctiva of the upper lid may be seen by turning back the lid.

5. *Sclerotica*, *cornea*, *pupil*, *iris*, etc.

2. Notice the ready contraction and dilatation of the pupil under varying amounts of light.

3. Turn the inner part of the lower eyelid downwards, and by the aid of a mirror, the small "lachrymal point," or opening into the nasal duct, may be seen in your own eyes.

4. Notice the eye of a frog. Touch the eyeball with a pencil, and notice what it does. Observe the motions of its lids.

5. For *dissection*, get a fresh eye of an ox.

(1.) Notice the *cornea* in front.

(2.) The back part will be covered with fat.

(3.) Remove it and the remainder of the *sclerotic* coat may be seen.

(4.) Observe the *conjuctiva*, the continuation of the mucous membrane of the eyelids, and notice that in taking the eye from the orbit this membrane had to be cut. On dissecting it forwards it will be traced to the back part of the cornia.

(5.) The tendons of the four *straight muscles* will be seen to form a layer under the conjunctiva.

(6.) With a sharp knife cut away the conjnnctiva and muscles, and remove the fat around the *optic nerve*. Notice that the nerve passes into the ball on the side nearest the nose.

(7.) Cut down through the back part of the cornea, laying bare the front chamber of the eye, containing the clear *aqueous humor*.

(8.) Through the central part of the *iris* may be seen the front of the lens.

(9.) Just back of the cornea cut barely through the sclerotic and remove a strip of it from there to the optic nerve. It separates easily from the *choroid coat* beneath.

(10.) In the front part of the choroid, near the cornea, look for the pale fibres of the *ciliary muscle.*

(11.) With a small pair of forceps, pinch up the choroid coat. The thin membrane under it is the *retina.*

(12.) By tearing away a piece of the retina, the *vitreous humor* will be exposed.

(13.) With the cornea underneath, hold up the choroid and retina, cut forward through them as far as the uneven line, (*ora serrata*) about two-thirds of the distance from the back to the front of the eye. The vitreous humor is easily separated from the retina as far as this line, but in front of this, its thin outer coat, the *hyaloid membrane*, is attached to the *ciliary processes.*

(14.) Turning the eye with the cornea above, cut away the free edge of the iris. Carefully make two incisions at right angles to each other through the front part of the *lens capsule*, the membrane covering the lens. Carefully remove the lens. Notice, (1) the difference in curvature between its front and rear surfaces, (2) the firmness of its tissues, and (3) its transparency.

(15.) Lay the lens on a piece of newspaper and look through it at the letters.

(16.) Place the lens in a solution of potassium bichromate for a week, and the lens fibres will peel off in laminæ.

6. Remove the scleratic coat from the eye af an ox, and place it in the end of a tube, blackened so that the back part may be darkened. The inverted image formed may be seen through the remaining parts. If the eye of a cat or rat be used, the sclerotic coat need not be removed.

7. The formation of an *inverted image* on the retina of the eye by the refracting media in front may be illustrated by a common hand-lens throwing the image on a window on a sheet of paper.

8. Prove the existence of the "*blind spot*" in the retina by closing one eye and looking steadily at one of two spots drawn upon the black-board at a convenient distance apart in a horizontal direction, at the same time keeping the attention fixed upon the other spot. If the right eye is closed and the left eye directed to the right spot, the left-hand spot will disappear when the peraon stands at a distance from the board equal to about three or four times the distance between the spots.

9. Look steadily at a bright light for a few seconds, and close the eyes. A gleam of light will be seen. What does this show?

10. Take a round piece of white card-board, as large as a saucer, and paint it alternate rings of red and yellow—two primary colors. Put it on a sewing-machine wheel, and rotate it rapidly. The eye perceives neither color, but orange, the secondary color.

NEGATIVE AFTER-IMAGES.

11. Place a small black card on a sheet of white paper, and look fixedly at it for a half minute or more. Now withdraw the black card, and keep the eyes fixed upon the spot which was covered by it. This spot will now appear bright. What is the cause?

12. Look steadily, for thirty seconds, at a white card on a black ground, and then look at a white surface. A dark patch will be seen on the white ground.

13. Vary the experiments by using cards of other colors.

14. By looking at a red card on a black ground, and then looking at a white surface, a blue-green patch will be seen.

15. Looking at a red patch on a black ground, and then turning to a yellow surface, a green patch will be seen.

16. To see the *shadows cast upon the retina by opaque matters* in the vitreous humor, look through a small pinhole in a card at a bright light covered by a ground-glass shads.

SHADOWS OF THE RETINAL BLOOD-VESSELS.

(Purkinje's figures.)

17. Look with one eye intently through a small hole in a card at the bright blue sky. Move the card very rapidly from side to side, or up and down. The shadows of the fine capillary retinal vessels will be seen on the card.

18. Go into a dark room with a lighted candle, and look steadily at a plain white blind, or wall, with one eye. Hold the candle so it will illuminate the side of that eye, but so the image of the candle will not be seen. Gently move the candle up and down, and in a few seconds branching dark lines will be seen to form an exact image of the retinal blood-vessels as seen by the ophthalmoscope. A cup-shaped space, in which the blood-vessels are absent, may with care be seen. This is the *yellow spot.*

19. ILLUSION OF THE EYE.—Look at the letter S and the figure 8. The upper part seems to be almost of equal size with the lower. Thus: SSSSS 88888. Now look at the same letters inverted, and notice the optical illusion. SSSSS 88888.

20. Take a piece of thick card, or, still better, of tin-foil; prick two very small holes *close together* in it—hold a small object, as a very small bright steel bead or pin-head, behind and near these holes—when properly adjusted and looked at from the right distance through these holes, *two* pin-heads will be seen. This arises from the light reflected from the pin's head being divided and bent round (*diffracted*) by the edge of the card so that the pencils of light reflected from the pin-head are split up into *two* portions, each of which forms a distinct *image* on the back of the eye.

21. Notice the difficulty in seeing clearly on going suddenly into the dark from a bright light. This is due to the absence of *visual purple*, which is formed during darkness and renders *the retina very sensitive* to light.

22. Notice the inability to see distinctly after suddenly passing from darkness into a brilliantly lighted room. This is due to the hypersensitiveness of the retina caused by the great accumulation of *visual purple*.

THE EAR.

1. The bones and membrane of the middle ear may be seen by dissecting the head of a rabbit or some other mammal.

2. In the frog the smooth round spot on each side of the head is the *tympanic membrane*. Make a small opening in one of those membranes, pass a bristle through the opening, and look for its appearance in the mouth. The wide opening through which it appears, is the *eustachian tube*. The frog does not have the chain of bones, but a little rod takes their place.

3. The *tympani* or ear-drums of the grasshopper may be seen under the bases of the wings, on the first abdominal ring. They are shiny, oval membranes.

4. With a lens look for the so-called hearing organ on the tibia of the cricket's foreleg.

5. Prove that sounds are transmitted through solid bodies and through the bones of the head better than through the air, by holding a long stick between the teeth and having some person scratch slightly on the other end with a pin.

Observe that if the stick is held in the teeth, the intensity of the sound is increased by closing the external ears—probably because the sound-waves passing out through the external meatus are reflected back upon the membrana tympeni.

6. TELEPHONE.—Get two round oyster cans, and melt out their ends. Stretch a piece of writing paper when wet, over one end of each and fasten by means of a string tied tightly around the edge of the can. Pass a string of any kind from the center of the paper head of one can to the head of the other. The string may be fastened to the paper by passing it through and tying a knot on the inside. Do not put the string through until the paper is dry. You now have the acoustic telephone and by means of it two persons can carry on a conversation at a distance of several hundred feet. The string should hang free so that it may vibrate. If it is necessary to pass around a corner suspend the string by means of a *short* piece of string attached to a projection. The person speaking at one end sets the air vibrating, which acting on the paper, causes it to vibrate, and this is communicated through the string to the other paper which is in turn set vibrating and its vibrations being communicated to the air again is received as sound and heard by the ear placed at the mouth of the can.

7. For a distance of not over one-fourth mile, a telephone made according to the following directions will be satisfactory and useful;—

Get a piece of good smooth pine board, 16 by 13 inches, and 5/8 inches thick. Cut a hole in it, 9 inches in diameter. To the ends of the board nail strips of the same kind of wood, 3 inches wide by 1/2 inch thick and 13 inches long. Varnish the board. Buy a finished calf skin drum-head at a music store. Or in butchering time inflate a hog's bladder, and use it when dry, or get one from your butcher. The bladder will not do quite as well as the drum-head, but nearly. Perhaps you have an old drum in the house that has become useless; if so, take the heads off it. Cut a piece large enough to tack over the hole in the board. Tack it down tightly and smoothly, drawing the tacks about half an inch from the edge of the skin. Punch a hole through the center of the skin about a quarter of an inch in diameter. Take a piece of tin about the size of a copper cent and punch two holes through it. Pass a piece of copper wire several feet in lenth through the holes and twist the ends together. Draw the wire down through the hole on the calf skin and hang a weight of 30 pounds upon it. This is for the purpose of stretching the skin. Wet the skin thoroughly on both sides. It will stretch and form a concave surface. In several hours it will dry, when the weight can be removed. Now bore a half inch hole through the side of the house, and place your disc upon the wall, so that the hole in the disc comes exactly over the hole in the wall. Nail or screw the disc fast to the wall. Now take No. 15 copper wire and pass it through the hole in the

building and through the hole of the disc, and fasten the wire to a piece of metal, or a cent, or a button, having a hole bored through it. The wire must not touch anything solid on its entire length. Draw the wire tightly, so that the cent or the button is pulled tightly against the calf skin, and run the wire to the other disc in the building with which you are going to connect. Tighten the wire carefully and well, and fasten it at the other disc the same way as before described. Remember, the tighter the wire, the better will be yonr telephone.

Talk slowly and distinctly, holding the mouth about six inches from the button.

Some Common Poisons and their Antidotes.

(The pupils may be shown samples of some of the more common poisons, so that they will know them.)

1—*Acids*, as nitric, muriatic, sulphuric, oxalic, etc.

(1.) Drink a little water, or better, soap-suds.

(2.) Drink freely of magnesia in water, lime water, chalk water, etc.

(3.) Follow with flax-seed tea, or warm water.

(4.) Send for a physician.

2.—*Alkalies*, as potash, soda, lye, ammonia.

(1.) Drink weak vinegar or lemon juice.

(2.) Follow with castor oil, linseed oil, or thick cream.

3—*Arsenic*, as Paris green, fly-powder, rats-bane.

(1.) Drink large quantities of milk, white of eggs, or induce vomiting by warm water and mustard (half an ounce to a pint) or soap-suds.

4—*Copper*, as blue vitrol, verdigris, etc.

(1.) Use white of eggs, or soda, and milk freely.

5—*Laudanum*, as opium, paragoric, soothing syrup, etc.

(1.) Use mustard and warm water, or ipecac.

(2.) After vomiting use strong coffee freely.

(3.) Keep patient awake.

6—*Lead*, as white lead, sugar of lead, etc.

(1.) Use mustard and warm water, ipecac, or salt and water.

(2.) Follow vomiting with dose of Epsom salts.

7—*Matches*,

(1.) Use magnesia, chalk, whiting, or flour in water.

(2.) Follow with mucilaginous drinks.

8—*Mercury*, as calomel, corrosive sublimate.

(1.) Drink milk copiously.

(2.) Use white of eggs.

(3.) Use flour in water

9—*Prussic Acid.*

(1.) Give teaspoonful of hartshorn in pint of water.

(2.) Apply smelling salts to nose.

(3.) Dash cold water in face of patient.

10—*Gases*, as chlorine, carbonic acid gas, fumes of burning charcoal, sulphuretted hydrogen, illuminating gas, etc.

(1.) Cautiously inhale hartshorn for chlorine.

(2.) For others, pour cold water on the head, and cautiously administer stimulants.

(3.) Apply artificial respiration.

DISINFECTANTS.

Some of the common disinfectants should be observed by the pupil, and he should be shown how they are to be used.

1. *Carbolic acid*, and *chloride of lime* are among the best known, but there are also certain of the salts of iron and zinc, and the permanganate of potash that may be used.

2. *Sulphur* is much used for the fumigation of rooms that have been infected.

3. Another cheap disinfectant is a solution of *chloride of lead* It is inodorous, effective, and the cost is small. Take half a drachm of the nitrate and dissolve it in a pint or more of boiling water. Dissolve two drachms of common salt in a pail or bucket of water; pour the two solutions together, and allow the sediment to sink. A cloth dipped in this solution, and hung up in a room, will correct a bad odor promptly, or if the solution be thrown down a drain, or upon foul-smelling refuse, it will have the same effect.

4. The room to be purified with *sulphur* should be made as tight as possible, so that no fumes can escape, either by window, door, or chimney. Put three pounds of sulphur in an iron pot, which should not stand upon wood-work or

carpet, least they be burned, but in a large pan of ashes, or upon a layer of bricks ; on this sulphur pour a tablespoonful of alcohol. This is then set on fire, and everybody immediately withdraws from the room. The room should remain closed ten hours, after which it should be thoroughly aired before it is occupied, for the fumes of the sulphur are irritating to the lungs.

5. The chemicals above mentioned should be known and labeled as poisons. Many persons have been injured, if not killed, by incautiously or ignorantly drinking those that are of a liquid form.

6. *Heat* is one of the best, if not the best, disinfecting agents. Articles of bedding and furniture that cannot well be treated otherwise, can be purified by a long exposure to a temperature of 240° F. In some cities, especially in England, furnaces are made for the reception of bulky articles that have become infected.

7. *Fresh pure air* is another powerful agent. If woven fabrics, clothing, and the like are for a long time aired out of doors, they cease to be infective , probably by the enormous dilution, if not destruction, of the elements of danger.

HOW TO USE DISINFECTANTS.

1. *In the Sick-room.*—The most available agents are fresh air and cleanliness. The clothing, towels, bed-linen, etc., should, on removal from the patient, and before they are taken from the room, be placed in a pail or tub of the zinc solution, boiling hot, if possible. All discharges should either be received in vessels containing copperas solution, or, when this is impracticable, should be immediately covered with copperas solution. All vessels used about the patient should be cleansed with the same solution. Unnecessary furniture, especially that which is stuffed, carpets and hangings, should, when possible, be removed from the room at the outset; otherwise they should remain for subsequent fumigation and treatment.

2. *Fumigation* with sulphur is the only practicable method for disinfecting the house. For this purpose the rooms to be disinfected must be vacated. Heavy clothing, blankets, bedding, and other articles which cannot be treated with zinc solution, should be opened and exposed during fumigation, as directed below. Close the rooms as tightly as possible, place the sulphur in iron pans supported upon bricks placed in wash-tubs containing a little water, set it on fire by hot coals or with the aid of a spoonful of alcohol, and allow the room to remain closed for twenty-four hours. For a room about ten feet square, at least two pounds of sulphur should be used; for larger rooms, proportionally increased quantities.

3. *Premises.*—Cellars, yards, stables, gutters, privies, cesspools, water-closets, drains, sewers, etc., should be frequently and liberally treated with copperas solution. The copperas solution is easily prepared by hanging a basket containing about sixty pounds of copperas in a barrel of water.

4. *Body and Bed-clothing, etc.*—It is *best* to burn all articles which have been in contact with persons sick with contagious or infectious diseases. Articles too valuable to be destroyed should be treated as follows:

a. Cotton, linen, flannels, blankets, etc., should be treated with the boiling-hot zinc solution; introduce piece by piece, secure thorough wetting, and boil for at least half an hour.

b. Heavy woollen clothing, silks, furs, stuffed bed-covers, beds, and other articles which cannot be treated with the zinc solution, should be hung in the room during fumigation, their surfaces thoroughly exposed, and pockets turned inside out. Afterward they should be hung in the open air, beaten and shaken. Pillows, beds, stuffed mattresses, upholstered furniture, etc., should be cut open, the contents spread out, and thoroughly fumigated. Carpets are best fumigated on the floor, but should afterward be removed to the open air and thoroughly beaten.

5. *Corpses* should be thoroughly washed with a zinc solution of double strength; should then be wrapped in a sheet wet with the zinc solution, and buried at once. Metallic,

metal-lined, or air-tight coffins should be used when possible; certainly when the body is to be transported for any considerable distance.

APPENDIX NOTES.

1. **Pure Spring Water.**—"A country house is fortunate if it possess at a convenient distance a good, cool, copious spring. Nothing is more attractive or more serviceable on a Pennsylvania farm than the spring house; often jutting out from a bank or hillside, built low, but firmly, of gray stone, and shaded over by a few old trees. Within you see the clear, transparent pool of water, in its reservoir of stone, pure as the air or sky overhead; and around it, or carefully placed in it, the pans of milk or cream, or butter, waiting for family use. A draught from that supply, flowing out to make a limpid stream through the meadow below, gives more refreshment on a midsummer day than the most tempting beverage of man's contrivance. It has in it no horrors, no mockery, *only health.*"—*Our Homes.* HENRY HARTSHORNE, M. D.

2. **When Scum and Water Weeds are Harmful.** "According to Prof. W. G. Farlow, M.D., the flowering plants known as water weeds, both those that grow from the bottom of ponds and water-courses, and have distinct stems and leaves, and also those that float on the surface as scum, are under ordinary circumstances, harmless. They

may prove (1) troublesome or injurious by growing so luxuriantly as to choke up small streams and shallow ponds; (2) by serving as points of attachment or shelter for injurious small plants; and (3) by decaying in hot weather."

3. **Purification of Water by Filtering.**—The following *home-made* filter is advised by Dr. Parkes, the eminent sanitarian: "Take a large, common flower-pot, and put into it a bit of zinc gauze or a clean bit of flannel; then coarse gravel to the depth of about three inches; over that the same amount of white sand washed very clean; and next, four inches of charcoal in small fragments,—animal charcoal when it can be had. On the top of all, a piece of well-cleaned sponge may be placed, making sure that this is changed or thoroughly cleansed once in a week or two; more or less often, according to the impurity of the water."

"If the water be impure, it may be rendered sweet by charcoal powder." "This is one of the greatest and most beneficial discoveries of modern times, for which we are indebted to Mr. Lowiz of Petersburgh. Water which has a disagreeable odor, or has become putrid, may almost immediately be freed from its nauseous taste, as well as its bad smell, and be converted into good drinkable liquor, by the following process: Take some burnt charcoal, and reduce it to a fine powder. Mix about a tablespoonful of this powder in a pint of water, stir it well around, and suffer it to stand for a few minutes. Let it then run slowly through filtering paper into a glass, and it will be found quite trans-

parent, without any bad taste or smell, and perfectly pure for drinking. People may preserve the charcoal powder a long time in a small bottle well corked, and carry it with them when they travel."—*Art of Prolonging Life.* Note by ERASMUS WILSON, M.D.

4. **The Use of Alcohol as a Medicine.**—"*Under the pressing demands* of a progressive civilization, the hurry of business, the excitements of professional life, the exhaustion of the nervous system is enormous. Every agent that offers relief is eagerly sought, and stimulants and narcotics meet the demand. For a brief period they soothe and comfort, but the same agents that deceive into joy leave the victim in greater depression and with more lasting fatigue. Under their influence, the intellectual faculties are quickened, but, sooner or later, by their over-stimulation, mental weakness and sometimes imbecility results. The daily use of alcohol by those in *health* is needless, and often harmful. Wine is a stimulant to digestion. More food is taken than is needed for the growth of the body and the daily waste. All food taken in excess of the bodily requirements is not only useless, but positively injurious, for it becomes a burden on the organism, and leads to disease. Alcohol also interferes with the proper oxidation of the waste material by offering to the oxygen of the blood an easily burned carbohydrate. The alcohol is consumed while the waste material, which must be oxidized to prepare it for elimination, escapes perfect combustion, and there results accumulation

of poisonous compounds in the body, causing that class of ailments known as "waste diseases." This action of alcohol, harmful in health, leads to excellent results when properly used in disease, especially those characterized by high temperature and rapid emaciation. But, is there not danger that the use of alcohol, in the treatment of disease, may lead to habits of intemperance? Doubtless, such cases have occurred, but we must remember that these habits are not unfrequently referred to medical advice as the least unpleasant explanation of their origin. But when there is the least danger, the physician should be ever on his guard. He has the right to *pro*scribe as well as *pre*scribe, and it is better that a hundred men should be sick a few days longer than they otherwise might be than that *one* should get up a drunkard or an opium-eater."—Extract from an address delivered by PROF. J. A. MCCORKLE, on the *Use and Abuse of Narcotics and Stimulants:* Jan. 1884.

5. Moderate Drinking; its Dangers.—"It ia s mournful spectacle—that of the brave, ingenuous, high-spirited man sinking steadily down into the degradation of inebriety; but how many such spectacles are visible all over the land! And it is not in the character of those alone who are notorious drunkards that such tendencies appear. They are often distinctly seen in the lives of men who are never drunk. Sir Henry Thompson's testimony is emphatic to to the effect that 'the habitual use of fermented liquors, to an extent far short of what is necessary to produce intoxica-

tion, injures the body and diminishes the mental power.' If, as he testifies, a large proportion of the most painful and dangerous maladies of the body are due to 'the use of fermented liquors, taken in the quantity which is conventionally deemed moderate,' then it is certain that such use of them must result also in serious injuries to the mental and moral nature. Who does not know reputable gentlemen, physicians, artists, clergymen even, who were never drunk in their lives, and never will be, but who reveal, in conversation and in conduct, certain melancholy effects of the drinking habit? The brain is so often inflammed with alcohol that its functions are imperfectly performed, and there is a perceptible loss of mental power and of moral tone. The drinker is not conscious of this loss; but those who know him best are painfully aware that his perceptions are less keen, his judgements less sound, his temper less serene, his spiritual vision less clear, because he tarries every day a little too long at the wine. Even those who refuse to entertain ascetic theories respecting these beverages may be able to see that there are uses of them that stop short of drunkenness, and that are still extremely hurtful to the mind and the heart as well as the body. That conventional idea of moderation, to which Sir Henry Thompson refers, is quite elastic; the term is stretched to cover habits that are steadily despoiling the life of its rarest fruits. The drinking habit is often defended by reputable gentlemen to whom the very thought of a debauch would be shocking, but to whom, if it were only law-

ful, in the tender and just solicitude of friendship, such words as these might be spoken : 'It is true that you are not drunkards, and may never be; but if you could know, what is too evident to those who love you best, how your character is slowly losing the firmness of its texture and the fineness of its outline ; how your art deteriorates in the delicacy of its touch; how the atmosphere of your life seems to grow murky and the sky lowers gloomily above you,—you would not think your daily indulgence harmless in its measure. It is in just such lives as yours that drink exhibits some of its most mournful tragedies.' "—*The Century*.

6. Alcohol of Little Value in Maintaining Animal Heat.—"My first illustration was obtained through Sir John Richardson, a medical officer high in our naval service, who was early associated with Sir John Franklin in Arctic exploration. It was then his conclusion that, even under extreme privation, the use of alcoholics did much more harm than good; so that it was better to burn the alcohol in a lamp, and to heat tea or some other liquid with it, and by drinking this to get a real heating effect, than to put the alcohol into the stomach. For what heat they got from one was so much gain; while the other, being only a stimulant, was followed by a depression which made the cold seem only more severe. On another expedition (the first sent to look for Franklin), Sir John Richardson passed the winter with a party in the north of America, as near the borders of the Icy Sea as they could reach. They were well supplied

with food, and lived in a log-house which had been built for them by our Hudson's Bay Company. Sir John had made it a strict condition that his party should go out upon strictly total abstinence principles; he would not have any spirits at all. It was a part of his work through the winter to make a series of magnetic observations; and it was necessary that the magnetic observatory should be at a short distance from the house, in order to avoid the local attraction of iron. Sir John told me that he was accustomed to go out at night from the house to the magnetic observatory—as it were, to go across the street, where he would make his observations, and return—without even putting on his great-coat. I asked him how cold was the temperature to which he exposed himself. He said that the temperature in the log-house was about fifty degrees above zero, and that outside it would sometimes be about fifty below zero. There was a change of *a hundred degrees*, which he found he was able to endure for a quarter of an hour without putting on his great-coat. That will show the kind of evidence which I proceeded upon. Many of our Arctic voyagers have given the same experience. Sir Joseph Hooker, who served with Captain James Ross in his Antarctic expedition about forty years ago, has given me evidence of nearly the same kind. And we have now the scientific *rational* of these facts, in the proof obtained by chemical means, that the alcohol taken into the body is not burned at all, but is expelled from it as a substance foreign to its constitution."—

The Physiology of Alcoholics, by WM. B. CARPENTER, M.D., L.L.D., F.R.S.

7. Cigarette Smoking.—"Scarcely less injurious, in a subtle and generally unrecognized way, than the habit of taking 'nips' of alcohol between meals, is the growing practice of smoking cigarettes incessantly. It is against the habit of smoking cigarettes in large quantities, with the belief that these miniature doses of nicotine are innocuous, we desire to enter a protest. The truth is that, perhaps owing to the way the tobacco leaf is shredded, coupled with the fact that it is brought into more direct relation with the mouth and air passages than when it is smoked in a pipe or cigar, the effects produced on the nervous system by a free consumption of cigarettes are more marked and characteristic than those recognizable after recourse to other modes of smoking. A pulse-tracing, made after the subject has smoked a dozen cigarettes, will, as a rule, be flatter and more indicative of depression than one taken after the smoking of cigars. It is no uncommon practice for young men who smoke cigarettes habitually to consume from eight to twelve in an hour, and to keep this up for four or five hours daily. The total quantity of tobacco used may not seem large, but, beyond question, the volume of smoke to which the breath organs of the smoker are exposed, and the characteristics of that smoke as regards the proportion of nicotine introduced into the system, combine to place the organism very fully under the influence of the tobacco. A consid-

erable number of cases have been brought under our notice during the last few months, in which youths and young men who have not yet completed the full term of physical development have had their health seriously impaired by the practice of almost incessantly smoking cigarettes. It is well that the facts should be known, as the impression evidently prevails that any number of these little 'whiffs' must needs be perfectly innocuous, whereas they often do infinite harm." —*Lancet.*

8. The Results of Re-breathing Expired Air.— "If you want to see how different the breath breathed out is from the breath taken in, you have only to try a somewhat cruel experiment, but one which people too often try upon themselves, their children, and their work-people. If you take any small animal with lungs like your own,—a mouse, for instance,—and force it to breathe no air but what you have breathed already; if you put it in a close box, and, while you take in breath from the outer air, send out your breath through a tube into that box, the animal will soon faint; if you go on long with this process, it will die.

"Take a second instance, which I beg to press most seriously on the notice of mothers, governesses and nurses. If you allow a child to get into the habit of sleeping with its head under the bed-clothes, and thereby breathing its own breath over and over again, that child will, assuredly, grow pale, weak, and ill. Medical men have cases on record of scrofula appearing in children previously healthy, which

could only be accounted for from this habit, and which ceased when the habit stopped."—*Health and Education.* REV. CHAS. KINGSLEY.

9. The Germ Theory of Disease.—During the last few years, the germ theory of disease has rapidly been gaining ground. It is now, indeed, all but universally admitted that many of the diseases called zymotic, which comprises epidemic, endemic, and contagious diseases, owe their origin to germs introduced into the organization from without. For these germs, however, to take root as it were, to develop the animal organization must be prepared for their reception. The most efficacious preparation, no doubt, is a low state of vitality from defective nutrition. We are, throughout life, constantly receiving into the economy these germs of disease; but, if the nutritive functions are sound, and the organization is healthy, it resists their presence and action. They do not find in it a suitable nidus wherein to germinate, so they are destroyed or expelled. Following this train of thought, we arrive at the inevitable conclusion that to escape the attack of zymotic disease we must be in good health, that is, in a sound nutritive state.

10. The "Black Hole of Calcutta."—In 1756, one hundred and forty-six English prisoners in Calcutta were confined over night in an apartment about eighteen feet square and fourteen feet high, having but one small window. In the morning, there were alive *twenty-three* only of the strongest, who had been able to get near the window in the

struggle that had occurred for fresh air. And of these, nearly all died subsequently of a very low type of typhus fever, known as "putrid fever." The place of their imprisonment has ever since been known as the "Black Hole of Calcutta."

Of the one hundred and fifty passengers shut up in the steamer *Londonderry*, with hatches battened down during a stormy night in 1848, seventy-two died before morning.

11. The Air of Bedrooms, Hospital Wards, etc. The air escaping from the ventilator of a crowded room is said to be very offensive, and, if drawn through pure water, will taint it. The air of bedrooms sometimes becomes so contaminated at night that sleep is restless or broken. The admission of a little fresh air will at such times often enable one to sleep soundly. Little children, or feeble persons, having passed the night in a close room, are liable in the morning to headache, want of appetite, and a general feeling of debility.

At times, the walls, floors, and bedding of hospital wards become so permeated with poisonous organic matter that to stay in them is unsafe until a thorough disinfection has taken place.

12. Poisonous Wall Papers.—Within the last few years it has been demonstrated by physicians and chemists, both in this country and Europe, that wall papers (especially those that are roughened or "flocked" and of a bright green color) are at times poisonous, owing to arsenical sub-

stances in the coloring. The arsenic acts as a poison by being diffused in the dust of the rooms, or, as some believe, in a gaseous form as arsenuretted hydrogen, when it may be recognized by a "garlic-like or musty odor." The phenomena of arsenical disease ordinarily produced are similar to those attending a severe cold, vic., an irritation of the eyes and the lining membrane of the nose and throat. The irritation may extend to the bronchial tubes, lungs, and lower portions of the alimentary canal, or the poison may produce skin eruptions, or be absorbed in such quantity as to produce convulsions and various disturbances of the nervous system.

13. Devitalized Air in Dwellings.—"In many private houses, houses even of the well-to-do and wealthy, streams of devitalized air are nursed with the utmost care. There is the lumber-room of the house, in which all kinds of incongruous things are huddled away and excluded from light and fresh air. There are dark, understair closets in which cast-off clothes, charged with organic *debris* of the body, are let rest for days or even weeks together. There are bed-rooms overstocked with furniture, the floors covered with heavy carpets in which are collected pounds upon pounds of organic dust. There are dressing-rooms in which are stowed away old shoes and well-packed drawers of well-worn clothing. There are dining-rooms in which the odor of the latest meal is never absent, and from the side board and cup-boards of which the smell of decomposing fruit or

cheese is always emenating, etc., etc. Under such conditions thousands of families live, children grow up, and old people die. They may all go for years and suffer no acute disease, and those of the family whose duty calls them daily into the open air may even be healthy; but those who have to remain nearly all day in the devitalized atmosphere of the home, show the fact in paleness of face, languor of limb, persistent sense of weariness and dullness of spirit. Under such conditions acute disease, epidemic fever, or other actively dangerous malady need not occur unless it be introduced from without; but the home is ready for it if it be introduced."—*Diseases of Modern Life.*

14. **Prevention from Drowning.**—In the water the human body weighs about a pound. When it is a question of life or death, do not attempt to raise your body out of the water. One or both hands placed on a block of wood, a stool, or a chair will enable a person to keep the mouth and nose out of the water. This is all that is of vital importance until aid arrives. All persons should be trained, when in the water, to know and to have faith in its buoyant powers. In case of a wreck, know that an overturned or water-filled wooden boat will sustain more persons in the water than it will carry. Do not permit any one to climb on it, for that will jeopardize the safety of all hanging on to the wrecked boat.

15. **Bodies in the External Ear.**—The sooner a foreign body is out of the external auditory meatus the

better. To remove *wax*, introduce a few drops of glycerin and water into the meatus for two or three nights; then, with an ear-syringe, direct a stream of tepid water into the meatus obliquely against the walls, and thus the water will get behind the wax and wash it out. To direct the stream against the wax does but little good, and to direct it against the membrana tympani does positive injury. To remove peas, beans, beads, etc., is often a work of difficulty, for the outer third of the meatus is wide, the middle third contracted, and the inner third enlarged. The passage, having bony walls, cannot be expanded. If vegetable or animal materials remain, by the absorption of water they expand, and thus render their removal more difficult. Sometimes the body can be washed out by getting water back of the object. In other cases it may be floated out by filling the meatus with warm oil. If these fail, make a loop of twisted iron wire, introduce it into the ear, against one of the sides of the passage, turn it half around, noose the body, and jerk it out. If an insect or worm enters the meatus, fill the passage with warm oil, and the intruder will leave.

16. Bodies on the Surface of the Eyeball.—When foreign bodies, as dust, cinders, etc., lodge upon the surface of the ball, or beneath the lids, do not rub the part. Hold the lids open, while the eye is rolled either up and down or from side to side. In this way the fragment may be removed. If not, hold up the upper lid and blow the nose; if this fails, seize the lashes of the upper lid and draw it

away from the eye, then look down, and push the lower lid beneath the upper, and thus the lashes may brush out the body. If this is ineffectual, place a small pencil under the eyebrow, and quickly, by aid of the eyelashes, turn the upper lid over the pencil. Remove the offending body, if possible, with the corner of a moistened handkerchief. If this fails, summon a surgeon to remove the body. After the removal of the body, drop into the eye a drop of castor oil. This will ease the gritty sensation which persists after the removal of the foreign material.

17. Frost-Bite.—Frost-bite is usually manifested first upon parts unprotected by covering, as the face or ears, and especially the nose. In such case the skin first becomes red, from congestion of the dilated capillary vessels; next it becomes bluish, from arrest of the circulation, and afterwards of a dead-white hue. To restore circulation and sensibility, rub the frozen part with snow, or apply iced water. Keep the sufferer at first in a cold room, and let the return to a higher temperature be *gradual* and cautious, else *gangrene* may supervene.

18. Drowning.—Marshall Hall's "Ready Method" of treatment in asphyxia from drowning, chloroform, coal-gas, etc.

1st. Treat the patient *instantly on the spot*, in the *open air*, freely exposing the face, neck, and chest to the breeze, except in severe weather.

2d. In order *to clear the throat*, place the patient gently

on the face, with one wrist under the forehead, that all fluid, and the tongue itself, may fall forward, and leave the entrance into the windpipe free.

3d. *To excite respiration*, turn the patient slightly on his side, and apply some irritating or stimulating agent to the nostrils, *as dilute ammonia, etc.*

4th. Make the face warm by brisk friction ; then dash cold water upon it.

5th. If not successful, lose no time ; but, *to imitate respiration*, place the patient on his face, and turn the body gently, but completely *on the side, and a little beyond ;* then again on the face, and so on, alternately. Repeat these movements deliberately and perseveringly, *fifteen times only* in a minute. (When the patient lies on the thorax, this cavity is *compressed* by the weight of the body, and *ex*piration takes place. When he is turned on the side, this pressure is removed, and *in*spiration occurs.)

6th. When the prone position is resumed, make a uniform and efficient pressure *along the spine*, removing the pressure immediately, before rotation on the side. (The pressure augments the *ex*piration, the rotation commences *in*spiration.) Continue these measures.

7th. Rub the limbs *upward*, with *firm pressure* and with *energy*. (The object being to aid the return of venous blood to the heart.)

8th. Substitute for the patient's wet clothing, if possi-

ble, such other covering as can be instantly procured, each bystander supplying a coat or cloak, etc. Meantime, and from time to time, *to excite inspiration*, let the surface of the body be *slapped* briskly with the hand.

9th. Rub the body briskly until it is dry and warm, then dash *cold* water upon it, and repeat the rubbing.

Avoid the immediate removal of the patient, as it involver a *dangerous loss of time;* also, the use of bellows, or any *forcing* instrument; also, the *warm bath*, and *all rough treatment.*

19. Care of the Sick-Room.—The sick-room should be bright and airy. Other things being equal, it is best on the upper floors in case of some "catching" disease on the floor. Let it be on the sunny side of the house. If for any reason the light of the sun is temporarily to be avoided—as when the eyes are sensitive or have been operated upon—let the light be shut out by a proper arrangement of blinds or curtains. The air-supply to be breathed by the sick person should be pure. Those who, in health, find themselves in an impure air can quit it; they are not compelled to suffer from it; but a sick person may be incapable of recognizing the bad quality of the air, as well as helpless to free himself from it.

To keep the air pure, the windows should be opened as often as three times a day, care being taken to protect the patient from being chilled, while the room is being aired.

Unless the physician shall direct differently, one window —that most remote from the bed—should be open an inch or more both day and night, and in all seasons. The extent to which the sash shall be lowered must be governed largely by the weather and the direction of the wind.

A fire, in an open fireplace, except in summer weather, will be a great help towards keeping the air pure. The upward current through a chimney-flue, if unobstructed, is equal to or not far below 20,000 cubic feet per hour; an outlet sufficient for a room occupied by ten persons.

The inlet of air, however, must not be forgotten; otherwise the air of the room tends to become both impure and too thin. As our houses are generally constructed, the inlet of air is best secured by a window-sash being lowered from the top.

Take special care that no stationary wash-basin or other sewer-connected convenience is improperly plumbed, and that sewer gas cannot by any possibility escape into the sick-room.

The swinging of doors to create a current is not an efficient means of ventilation, as it agitates the air of the room without purifying it, and often disturbs the patient.

A draught of air is to be avoided; it will seldom occur that the air of the room requires to be so speedily changed that the patient need be exposed to a draught; never, when care

has been taken to provide continuous and gradual ventilation.

It should be born in mind that cold air is not neccessarily pure air, and that ventilation is not less needed in winter than in warm weather.

Sleep is a great necessity to the sick. If a well person slumbers in the day-time, it will interfere with his sound repose at night, but with the sick this is generally not the case. The more they sleep the more favorable are the chances for their recovery ; so that it will be readily seen how important it is to avoid noise and jar in the sick-room, especially if the disease is acute.

Bear in mind that even slight noises, as the rustling of garments, the creaking of doors, whispering, or noisy footfalls, may be sufficient to disturb a brain that is rendered sensitive by pain or wakefulness.

The patient's clothing next to the skin should be changed often.

The temperature of the room should not vary much from 65° F., unless the doctor otherwise directs.

THE END.